



Elements of Ambient Air Network Design

SC Department of Health and Environmental
Control

Bureau of Environmental Services

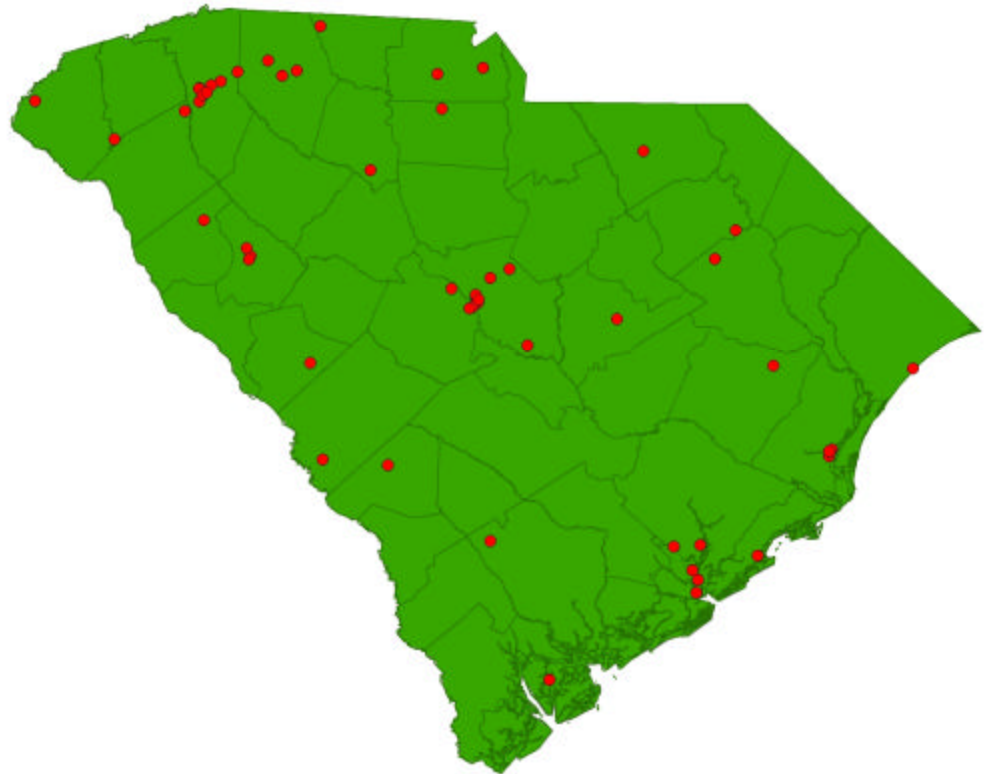
Bureau of Air Quality

March 15, 2006

Housekeeping

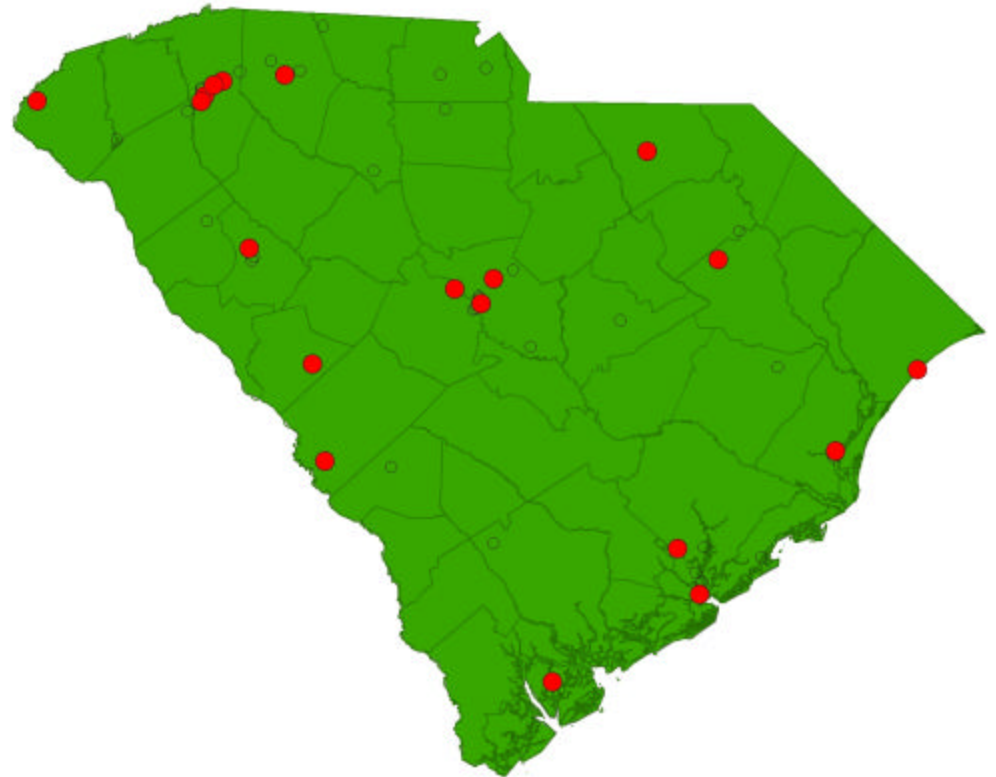
Why we're here

- **Network developed over time**



Why we're here

- **Network developed over time**
 - **PM_{2.5} the most recent statewide ‘ground-up’ monitoring network**



Why we're here

- Network developed over time
- **Needs have changed since the different parts of the network were developed**

Why we're here

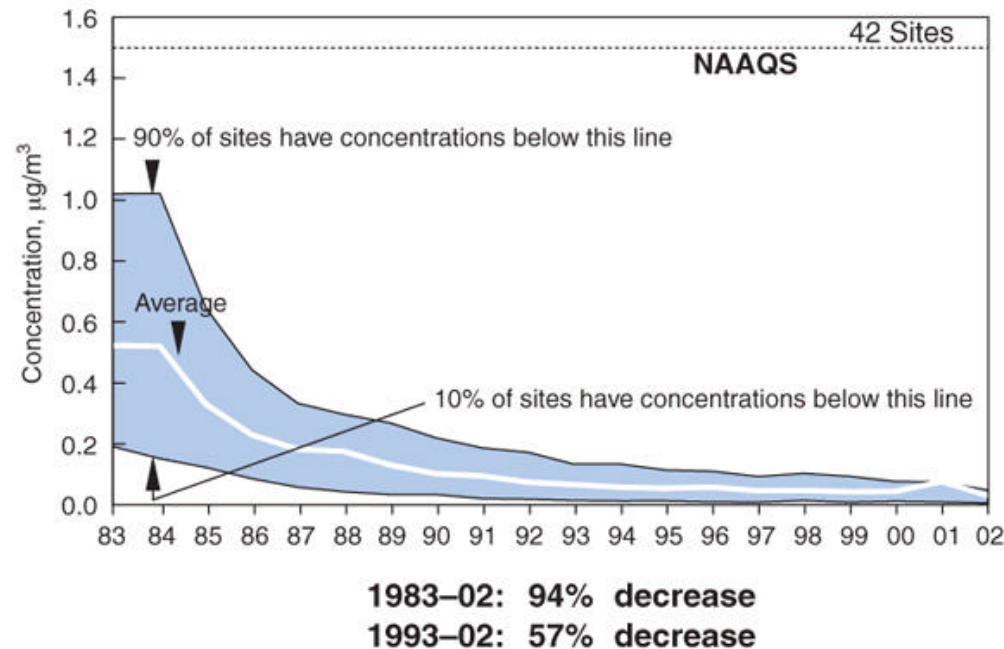
- Network developed over time
- **Needs have changed since the different parts of the network were developed**



Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
 - Some pollutant concentrations are well below health standards

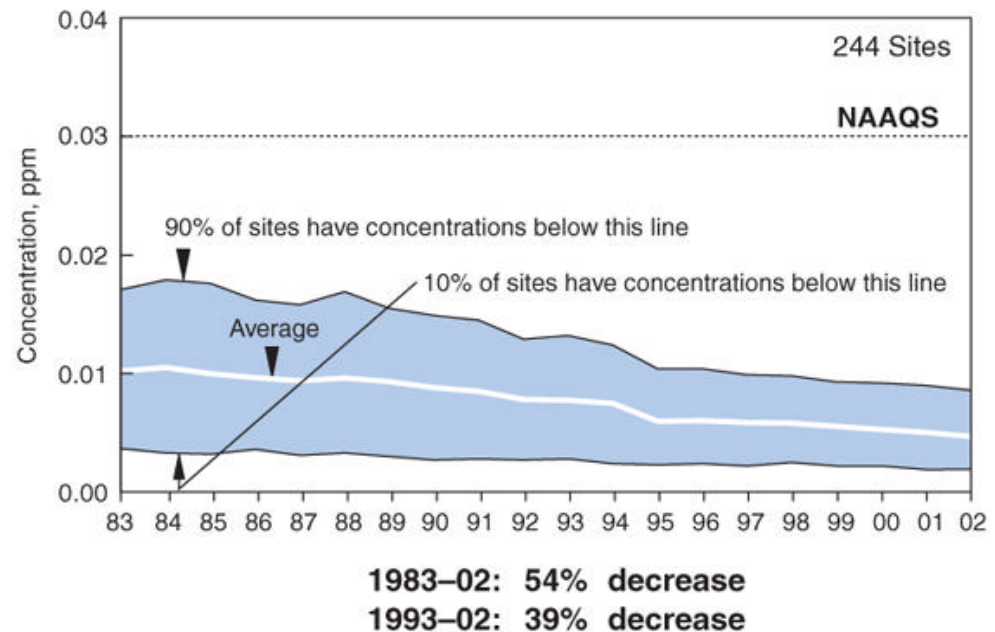
Figure 2-9. Pb air quality, 1983–2002, based on annual maximum quarterly average.



Why we're here

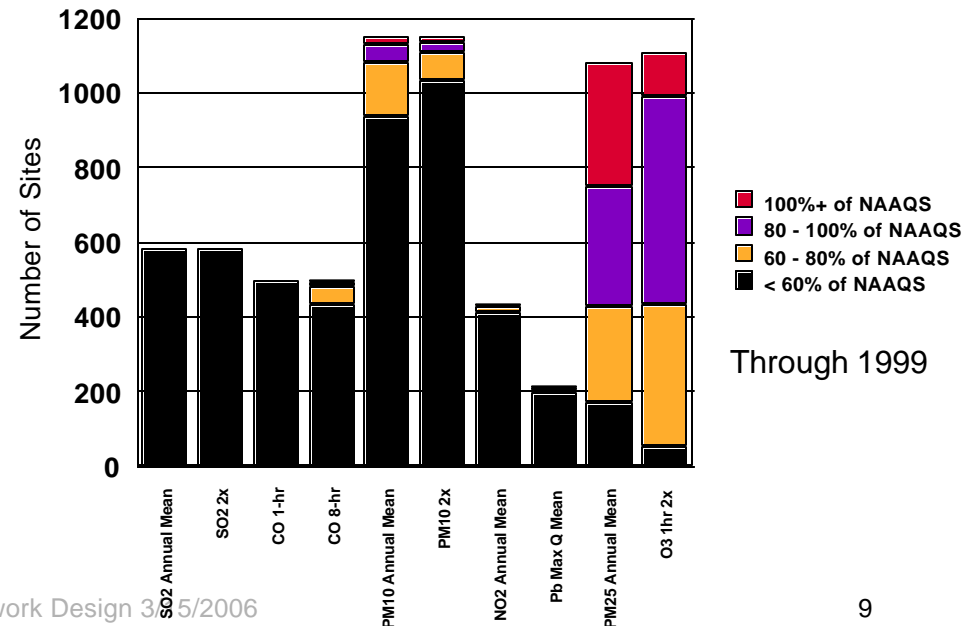
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Figure 2-51. SO₂ air quality, 1983–2002, based on annual arithmetic average.



Why we're here

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 - Monitoring for those parameters may now serve a different purpose - different questions require different design

Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
 - Some pollutant concentrations are well below health standards
 - Monitoring for those parameters may now serve a different purpose - different questions require different design
 - Original objective may still be a concern

Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
- **Specific questions need answers to be able to continue to meet the standards**

Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
- **Specific questions need answers to be able to continue to meet the standards**
 - What are the significant sources?
 - Are the strategies having having an impact?

Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
- Specific questions need answers to be able to continue to meet the standards
- **Proposed changes to ambient air standards and monitoring requirements**

Why we're here

- Network developed over time
- Needs have changed since the different parts of the network were developed
- Specific questions need answers to be able to continue to meet the standards
- Proposed changes to ambient air standards and monitoring requirements
- **The required network may not be enough...**

Don't plan to talk about :

- **Specific Pollutants**
- **Specific Areas**
- **Specific Sites**
- **Specific Monitoring Methods**
- **Specific Guidance**

Don't plan to talk about :

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- **Specific Areas**
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...other than as examples to illustrate an element of Network Design.

Ambient vs. other monitoring

–Is

- **Potential public exposure**

Ambient vs. other monitoring

–Is

- **Potential public exposure**

– Is usually

- **Parameters that have standards**

Ambient vs. other monitoring

–Is

- **Potential public exposure**

– Is usually

- **Parameters that have standards**

–Is not

- **Indoor**
- **On facility grounds**

Outline of approach

Briefly...

- What we monitor**
- Why we monitor**
- How we monitor**
- Elements of Network Design and Review**
- Practical considerations**
- Next steps in the review of the SC Ambient Air Monitoring Network**

Conventions and Resources

- **A Network is ...**
- **Monitor vs. Sampler**
- **Required, extra and things in proposed rule**
- **There WILL be acronyms**
- **References**
 - **DHEC Web Site**
- **Disclaimer** The mention or use of any equipment or images of equipment is not an endorsement or recommendation by the SC DHEC or the Division of Air Quality Analysis.

Conventions and Resources

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Questions ?

Questions !

Questions drive monitoring design

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State the Problem....

Objectives...

Questions !

Questions drive monitoring design

State the Problem....

Questions !

Questions drive monitoring design

Well defined questions dictate the
What, Where, How often, and
How long of Monitoring Network
Design ..

WHAT

What we monitor

- Criteria Pollutants
 - National Ambient Air Quality Standards
- Noncriteria Pollutants
 - Everything else that may be a problem..
- Related parameters
 - ...or may be of interest and help us understand.

Criteria Pollutants have NAAQS

- **Health is Primary**
 - Based on the latest studies
 - Protective of sensitive populations
 - Address acute and chronic exposure
- **Welfare is Secondary**
 - Same as above, but...
...for the environment and property

NAAQS

National Ambient Air Quality Standards

– Sulfur Dioxide	SO_2
– Nitrogen Dioxide	NO_2
– Carbon Monoxide	CO
– Ozone	O_3
– Lead	Pb
– Particulate Matter less than 10 microns	PM_{10}
– Particulate Matter less than 2.5 Microns	$\text{PM}_{2.5}$

NAAQS

National Ambient Air Quality Standards

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– Particulate Matter less than 10, but greater than 2.5 microns	$\text{PM}_{10-2.5}$

SC Standards

State Ambient Air Quality Standards

– Total Suspended Particulate	TSP
– Gaseous Fluorides (as HF)	F⁻
– Ozone (1 Hour)	O₃
– Sulfur Dioxide	SO₂
– Nitrogen Dioxide	NO₂
– Carbon Monoxide	CO
– Ozone	O₃
– Lead	Pb
– Particulate Matter less than 10 microns	PM₁₀
– Particulate Matter less than 2.5 microns	PM_{2.5}

Other Parameters

- **Pollutants**

- **Toxics**
 - **Organic compounds**
 - **Volatiles**
 - **Semivolatiles**
 - **Carbonyls**
 - **Metals**
 - **Mercury**
 - **Chromium⁺⁶**

Other Parameters

- **Pollutants**
- **Effects**
- **Acid Precipitation**
- **Visibility**
- **Soiling**

Other Parameters

- Pollutants
- Effects
- Components
 - Components of fine particulate
 - Speciation
 - *IMPROVE*
 - *STN*
 - Monitoring
 - Sulfate
 - Black Carbon

Other Parameters

- **Pollutants**
 - **Effects**
 - **Components**
 - **Precursors**
- **Ozone**
 - **Oxides of Nitrogen**
 NO_2 , NO_x , NO_y , NO
 - **Reactive Hydrocarbons**
 - **Particulate**
 - SO_2
 - NO_2
 - NH_3
 - **Hydrocarbons**

Other Parameters

- **Pollutants**
 - **Effects**
 - **Components**
 - **Precursors**
 - **Supporting Information**
- **Meteorology**
 - **Wind Speed, Direction**
 - **Temperature**
 - **Humidity**
 - **Insolation**
 - **Upper air ...**
 - **Traffic counts**
 - **Local events**

Questions !

Questions drive monitoring design

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Questions drive monitoring design

- **Pollutants**
- **Effects**
- **Components**
- **Precursors**
- **Supporting Information**

WHY

Why we monitor

To answer questions (Provide data for...)

Why we monitor

To answer questions (Provide data for...)

Do we have a problem? :

(Comparison to the standards)

- **NAAQS set to be protective of public health**
- **most sensitive populations**
 - maximum concentrations
 - highest concentrations in areas with high population density

Why we monitor

To answer questions (Provide data for...)

Is Air Quality getting better or worse? :
(Tracking)

- long term trends
- impacts on communities
- effectiveness of programs
 - impacts of sources or source types
 - maximum concentrations
 - highest concentrations in areas with high population density

Why we monitor

To answer questions (Provide data for...)

What is contributing to Air pollution ?:

(Investigation)

- sources**
- precursors**
- interactions**
- complaints**
- impacts of sources or source types**

Why we monitor

To answer questions (Provide data for...)

Can we predict the Future:

(Modeling support)

- **Data for input**
- **Data to test**
 - spatial distribution
 - rural areas
 - background
 - transport

Why we monitor

To answer questions (Provide data for...)

Can we document an impact (PSD):

(Confirmation)

- **Monitor before**
- **Monitor after**

To answer questions...Provide data for

- **Comparison to the standards**
- **Tracking**
- **Investigation**
- **Confirmation**
- **Modeling support**

To meet these needs, we monitor:

- **Max concentration**
- **Max exposure to population**
- **Impacts of sources**
- **Transport**
- **Rural areas**
- **Pristine areas (Background)**

HOW

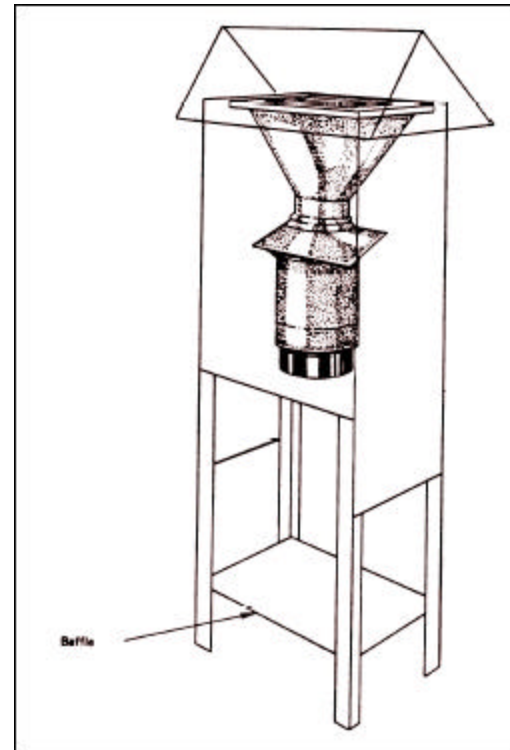
Samplers

- **Sensitive**
- **Inherent average measurement**
- **Sample must be collected and analyzed**



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Monitors

- **Fast response**
- **Data immediately available**
- **Data can be aggregated to longer time periods.**
- **Complex and expensive , but..**



Monitors

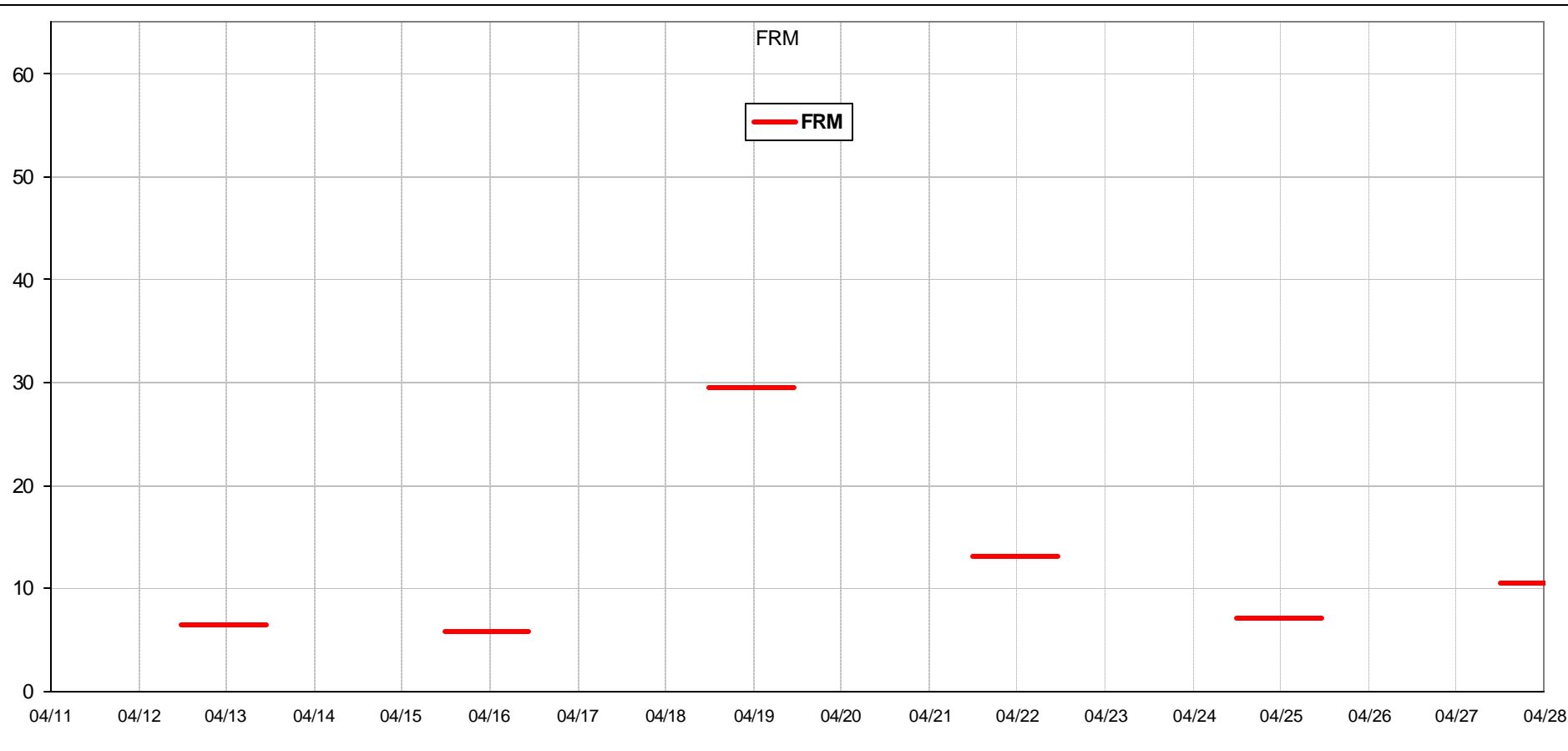


- **Complex and expensive , but..**

...the details can be important.

Monitors

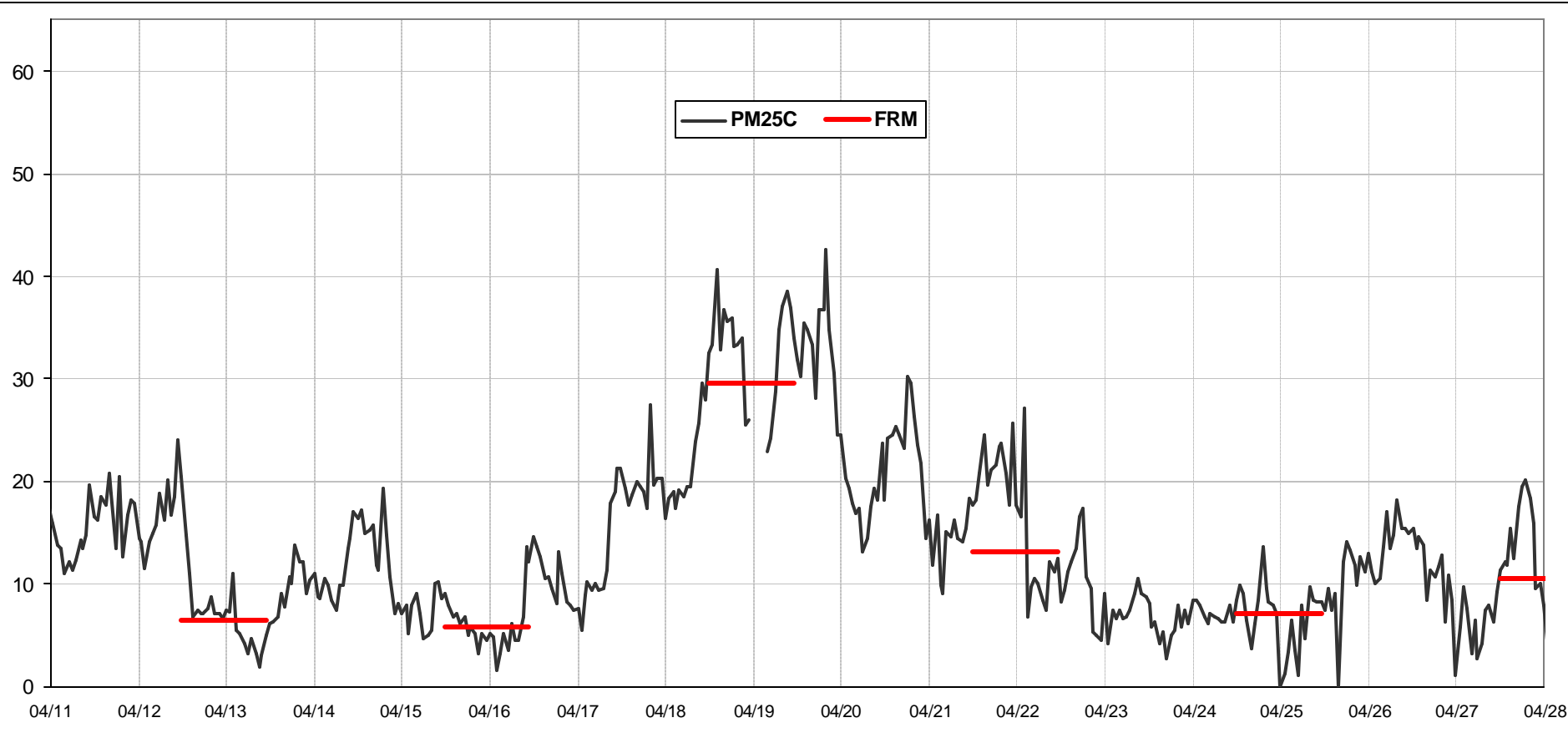
1:3 day sampling



...the details can be important

Monitors

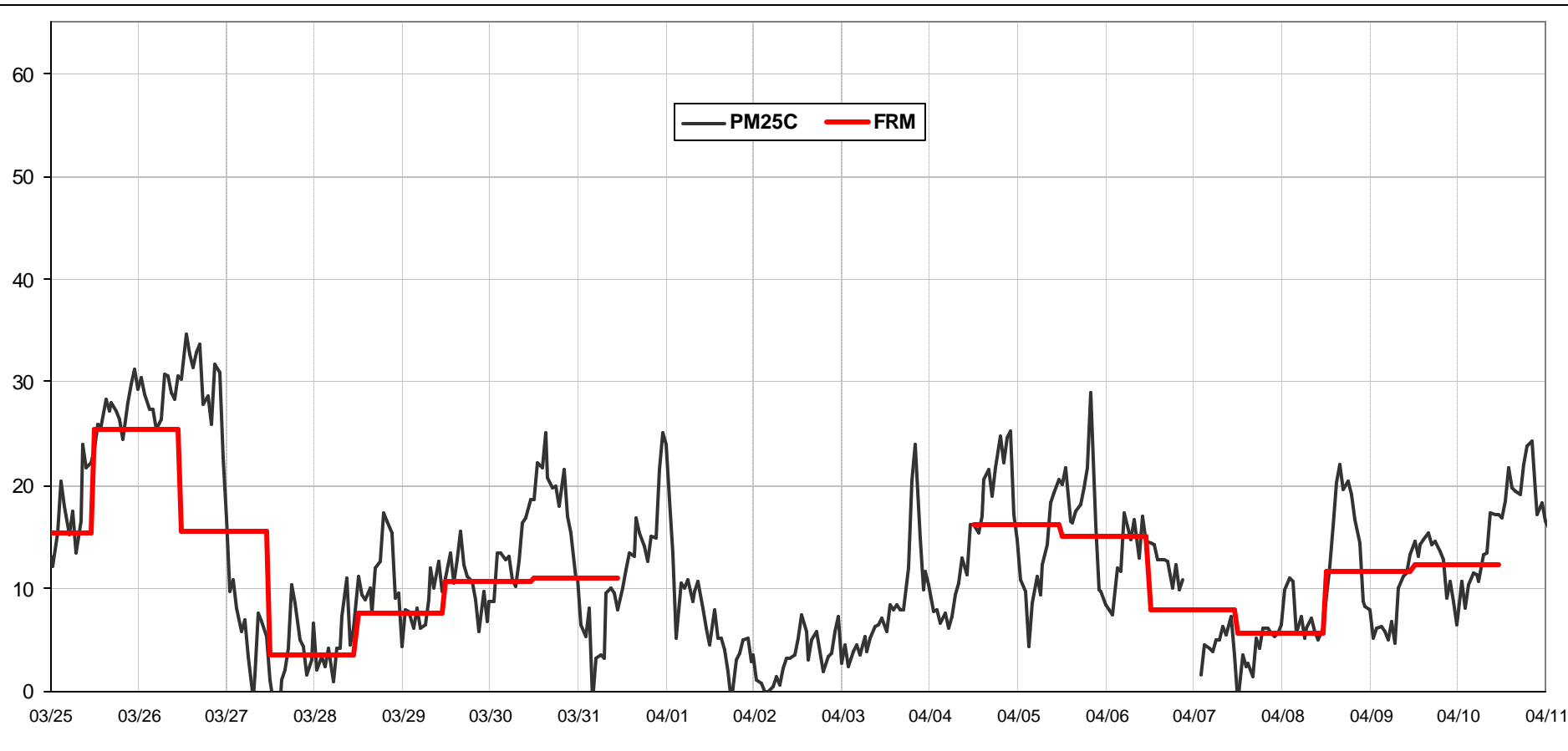
1:3 day sampling plus continuous



...the details can be important

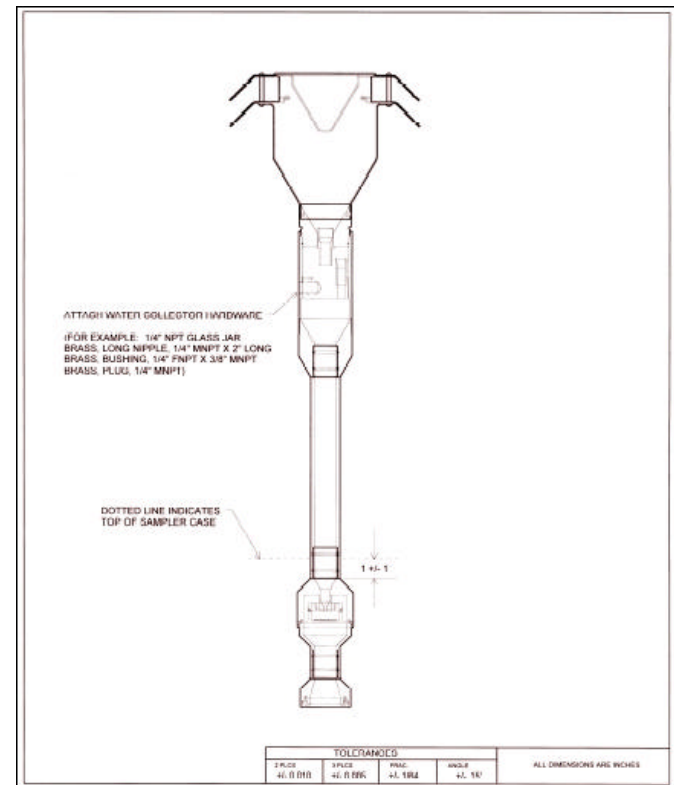
Monitors

1:1 day sampling plus continuous



Reference and Equivalent Methods for Criteria Pollutants

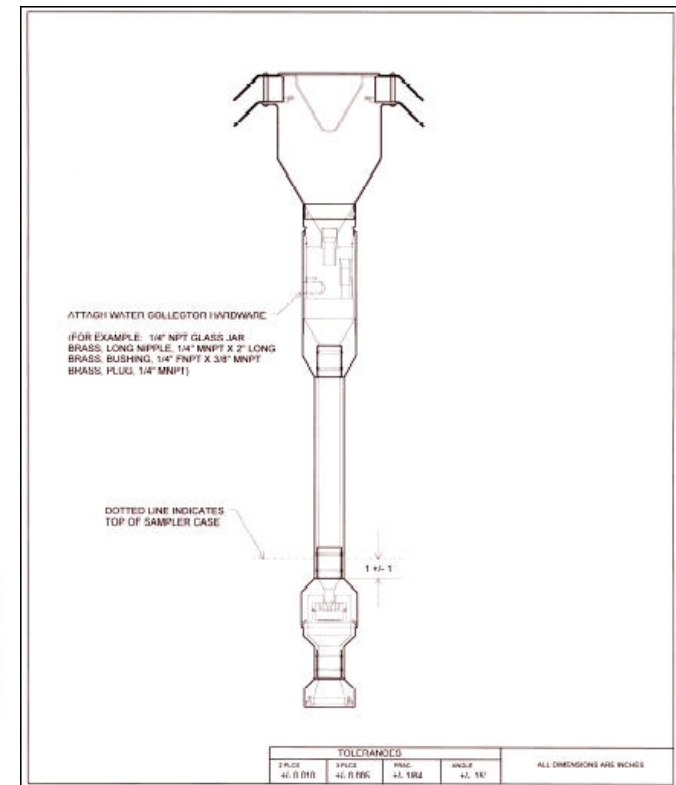
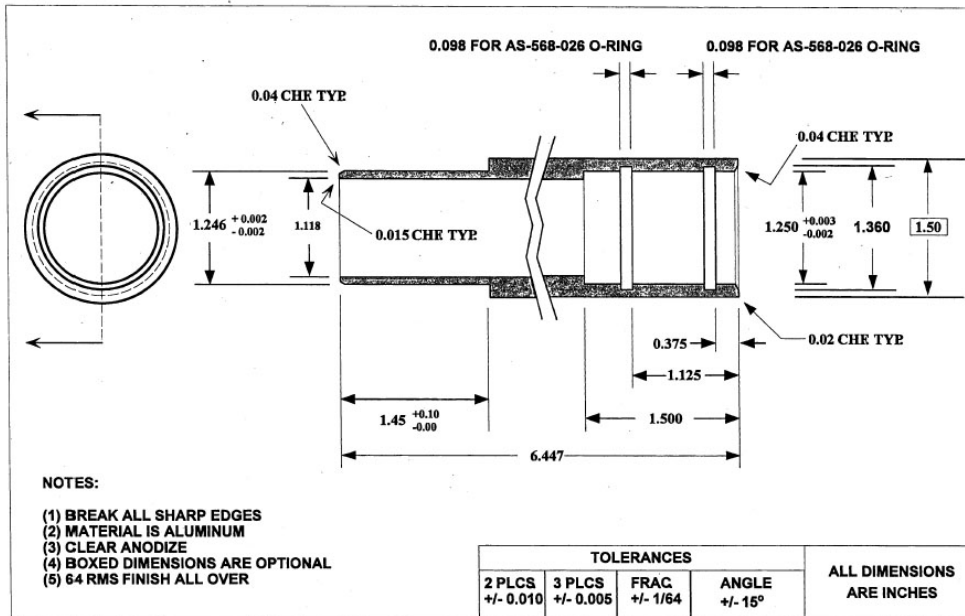
- THE method is specified. (40CFR Part 50)



Reference and Equivalent Methods for Criteria Pollutants

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FIGURE O-1.DOWNTUBE EXTENSION



Reference and Equivalent Methods for Criteria Pollutants

- THE method is specified. (40CFR Part 50)
- Candidate methods will be compared to the **Reference** Method to be ...

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Reference and Equivalent Methods for Criteria Pollutants

- THE method is specified (40CFR Part 50)
- Candidate methods will be compared to the **Reference** Method to be ...
- ..designated **Equivalent** when operated as specified. (40CFR Part 52)

The South Carolina Network uses Reference or Equivalent methods whenever possible

Standard methods for noncriteria pollutants

- Be part of national networks
 - Standardized methods
 - Quality Assurance
 - Data Management, Analysis and reporting
 - Designated funding may be available

Standard methods for noncriteria pollutants

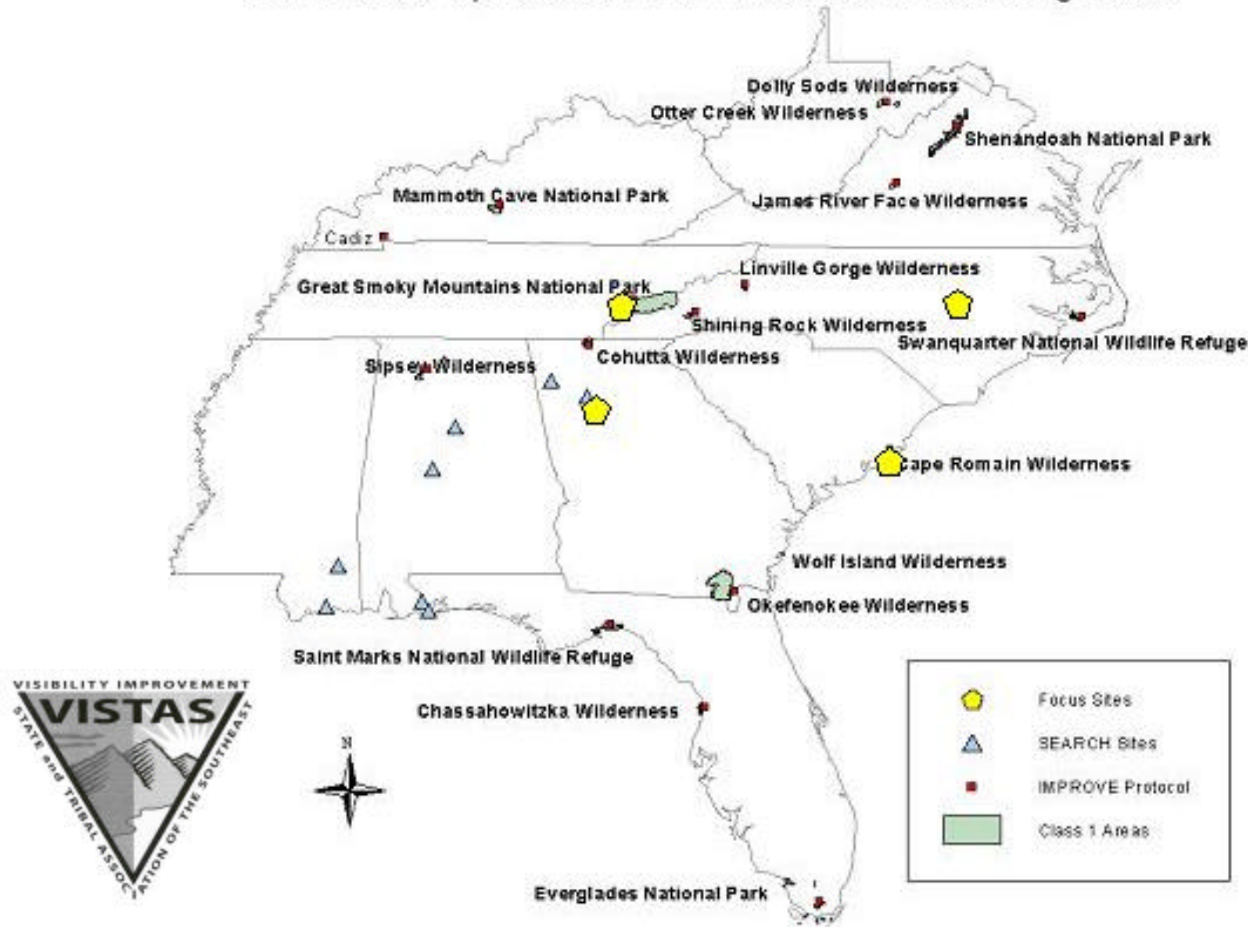
- Be part of national networks
 - NADP / MDN
 - National Air Deposition Program/Mercury Deposition Network
 - IMPROVE
 - Interagency Monitoring of Protected Visual Environments
 - NAATS
 - National Ambient Air Toxics Sites

Standard methods for noncriteria pollutants

- Be part of regional networks
 - Address specific needs
 - Improve capacity
 - Improve regional coordination
 - Improve regional consistency

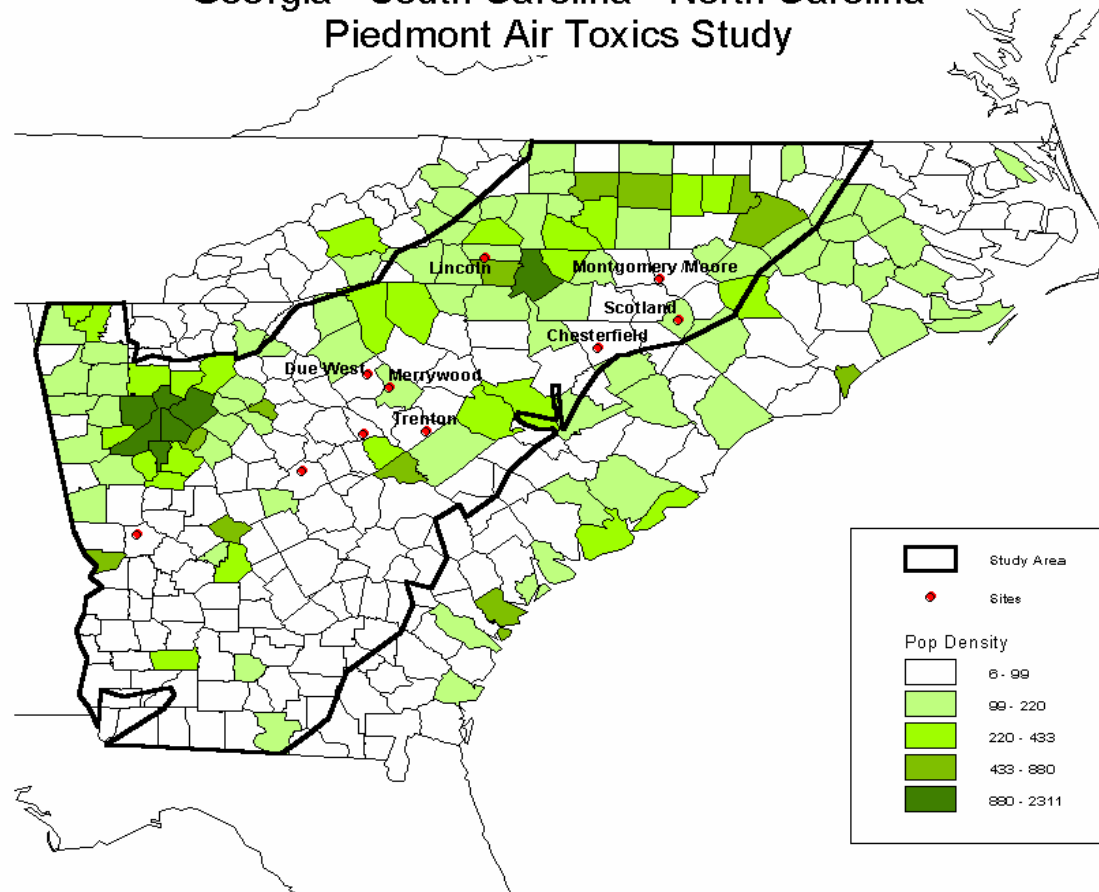
Regional Networks

Continuous Speciated Fine Particulate Monitoring Sites



Regional Networks

Georgia - South Carolina - North Carolina
Piedmont Air Toxics Study



Networks...

The designation or name
isn't important...

Each is a collection of
tools deployed to
provide information to
answer a question

NAMS
SLAMS
PAMS
IMPROVE
NDN
MDN
TSAT
Focus Sites
RAIN
CASTNET
AirMon
STN

Networks...

The designation or name
isn't important...

Each is a collection of
tools deployed to
provide information to
answer a question

- by parameter
- by area
- by question

ELEMENTS

In the beginning, is the **Question**:

- What MUST I do?

Part 58

You **will** monitor.

App A and B- You **will** do a good job.

App C – You **will** use Reference and
Equivalent methods

In the beginning, is the **Question**:

- What MUST I do?

Part 58

You **will** monitor.

App D- Sites should be here.

App E- The probe at the site should be...

App F- Report the data.

In the beginning, is the **Question**:

- What MUST I do?

Part 58

App D – Network Design for:

- **NAMS**
- **SLAMS**
- **PAMS**

- **SLAMS**
 - **State and Local Air Monitoring Stations**
- **NAMS**
 - **National Air Monitoring Stations**
- **SPMs**
 - **Special Purpose Monitors**
- **PAMS**
 - **Photochemical Assessment Monitoring Stations**

- **SLAMS**
 - **State and Local Air Monitoring Stations**
- **NAMS**
 - **National Air Monitoring Stations**
- **SPMs**
 - **Special Purpose Monitors**
- **PAMS**
 - **Photochemical Assessment Monitoring Stations**

Monitoring 'Stations'

- **The SITE just the location..**
 - monitors (or samplers) have an objective (not the site)**
 - multiple objectives may be met at one location**

Network requirements Pt 58 App.D

- **Objectives**

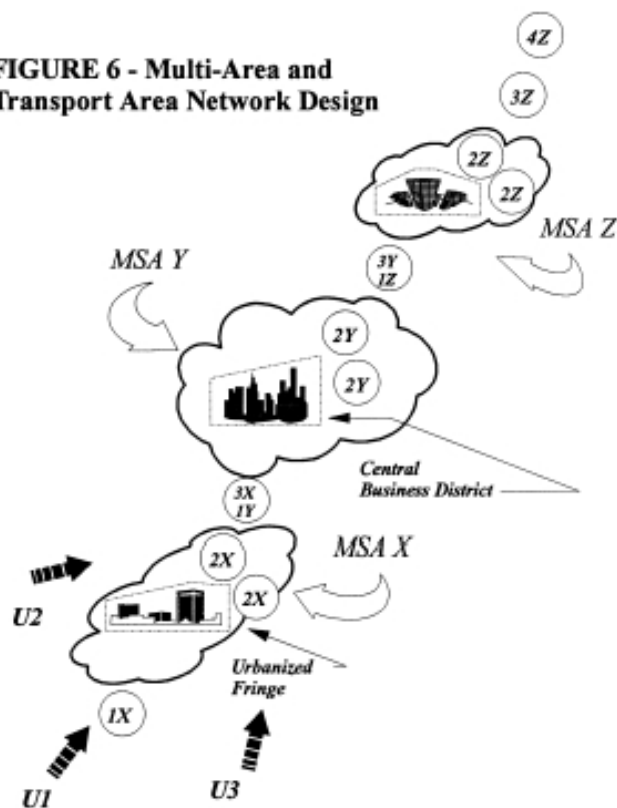
- **Max concentration**
- **Representative exposure of population**
- **Impacts of sources**
- **Background**
- **Transport**
- **Welfare impacts in rural and remote areas**

Network requirements Pt 58 App.D

Environmental Protection Agency

Pt. 58, App. D

FIGURE 6 - Multi-Area and Transport Area Network Design



LEGEND:

(1X) - A circle denotes a PAMS Site. The number inside describes the Site number and the letter indicates the associated MSA/CMSA, e.g., a circle with 1X indicates a Site #1 for MSA X. Since PAMS can serve multiple purposes for more than one MSA/CMSA, Sites with multiple associations are identified with multiple number and letter identifiers.

U1 - High ozone day predominant morning wind direction

U2 - Second most predominant high ozone day morning wind direction

U3 - High ozone day predominant afternoon wind direction

- Max concentration
- Representative exposure of population
- Impacts of sources
- Background
- Transport
- Welfare impacts in rural and remote areas

3/15/2006

Network requirements Pt 58 App.D

- **Objectives**

Each objective is associated with appropriate spatial scales of representativeness

- **Max concentration**
- **Representative exposure of population**
- **Impacts of sources**
- **Background**
- **Transport**
- **Welfare impacts in rural and remote areas**

Network requirements Pt 58 App.D

- **Scale**

‘..physical dimensions...
...throughout which actual pollutant concentrations are reasonably similar.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘ ...characterizing the nation and region as a whole.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘...rural area of reasonably homogeneous topography....tens to hundreds of kilometers.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘...on the order of 4
to 50 kilometers.

...usually require
more than one site
for definition.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘...relatively uniform
land use with
dimensions in the
0.5 to 4.0 kilometers
range.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘...several city blocks...dimensions ranging from about 100 meters to 0.5 kilometer.’

- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

‘..physical dimensions...’

‘... dimensions
ranging from
several meters to
about 100 meters.’

- **Micro**
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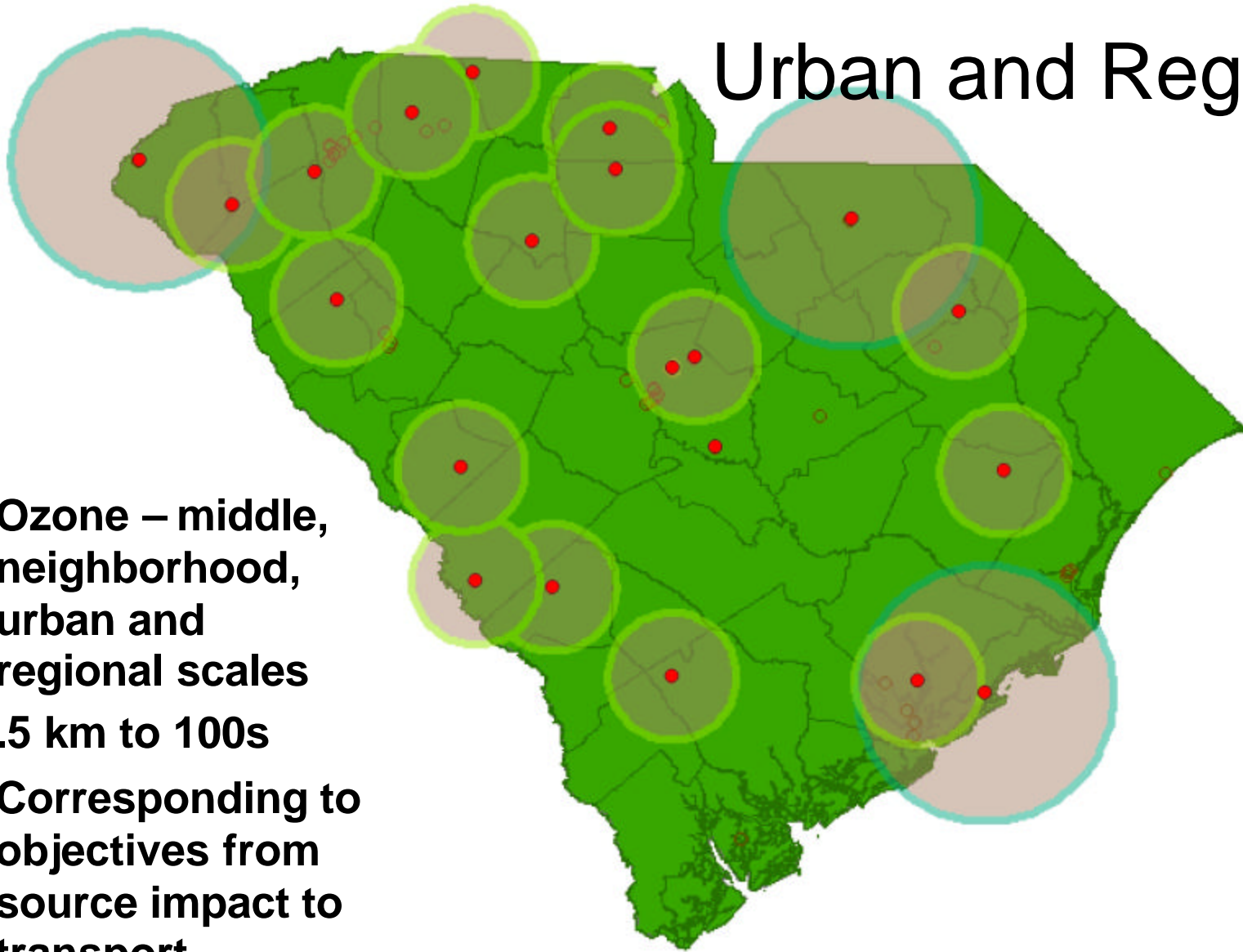
‘..physical dimensions...’

Used for quality assurance (QA) to define the precision of the method.

- **Collocated**
- **Micro**
- **Middle**
- **Neighborhood**
- **Urban**
- **Regional**
- **National/Global**

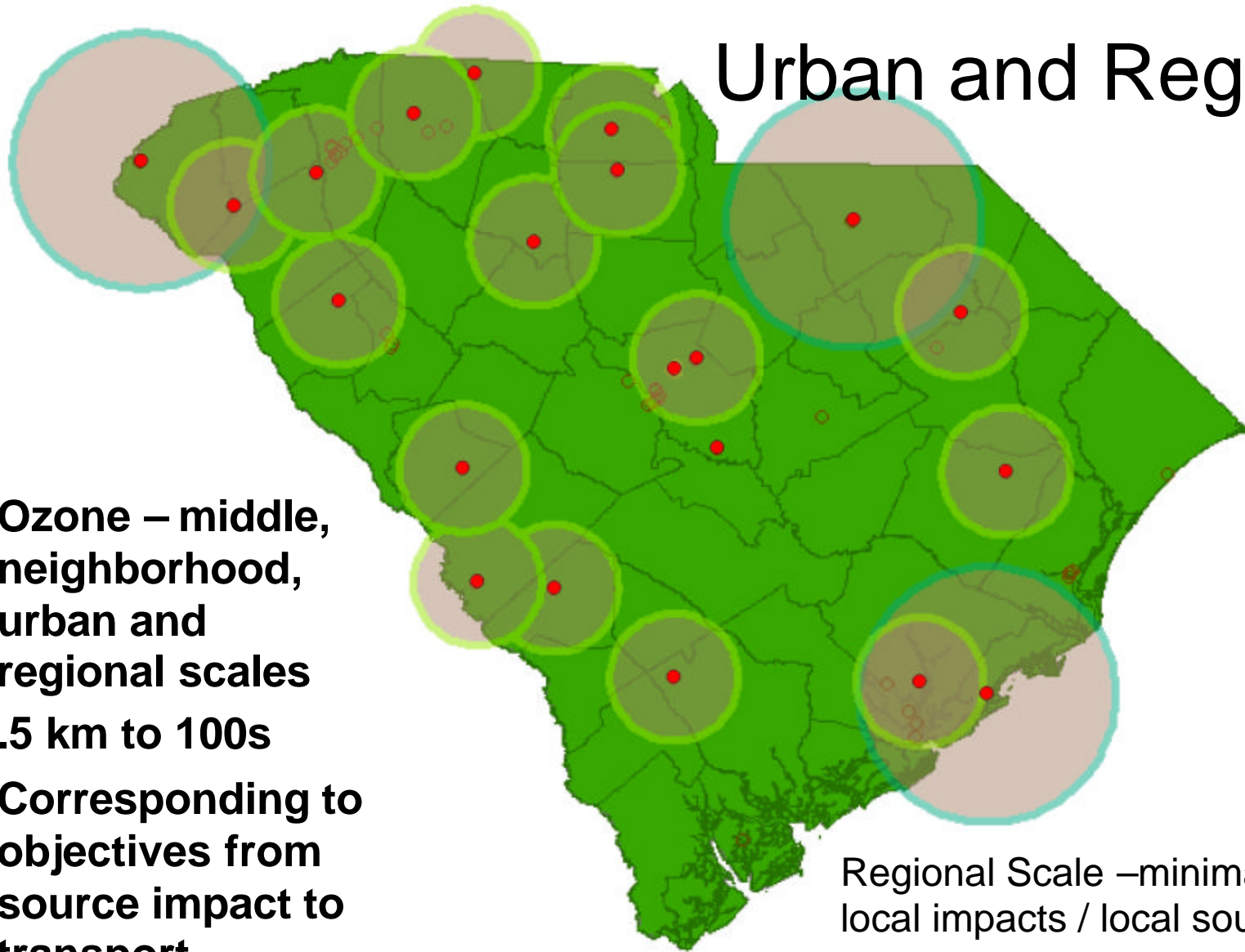
Urban and Regional

- **Ozone – middle, neighborhood, urban and regional scales**
- **.5 km to 100s**
- **Corresponding to objectives from source impact to transport**



Urban and Regional

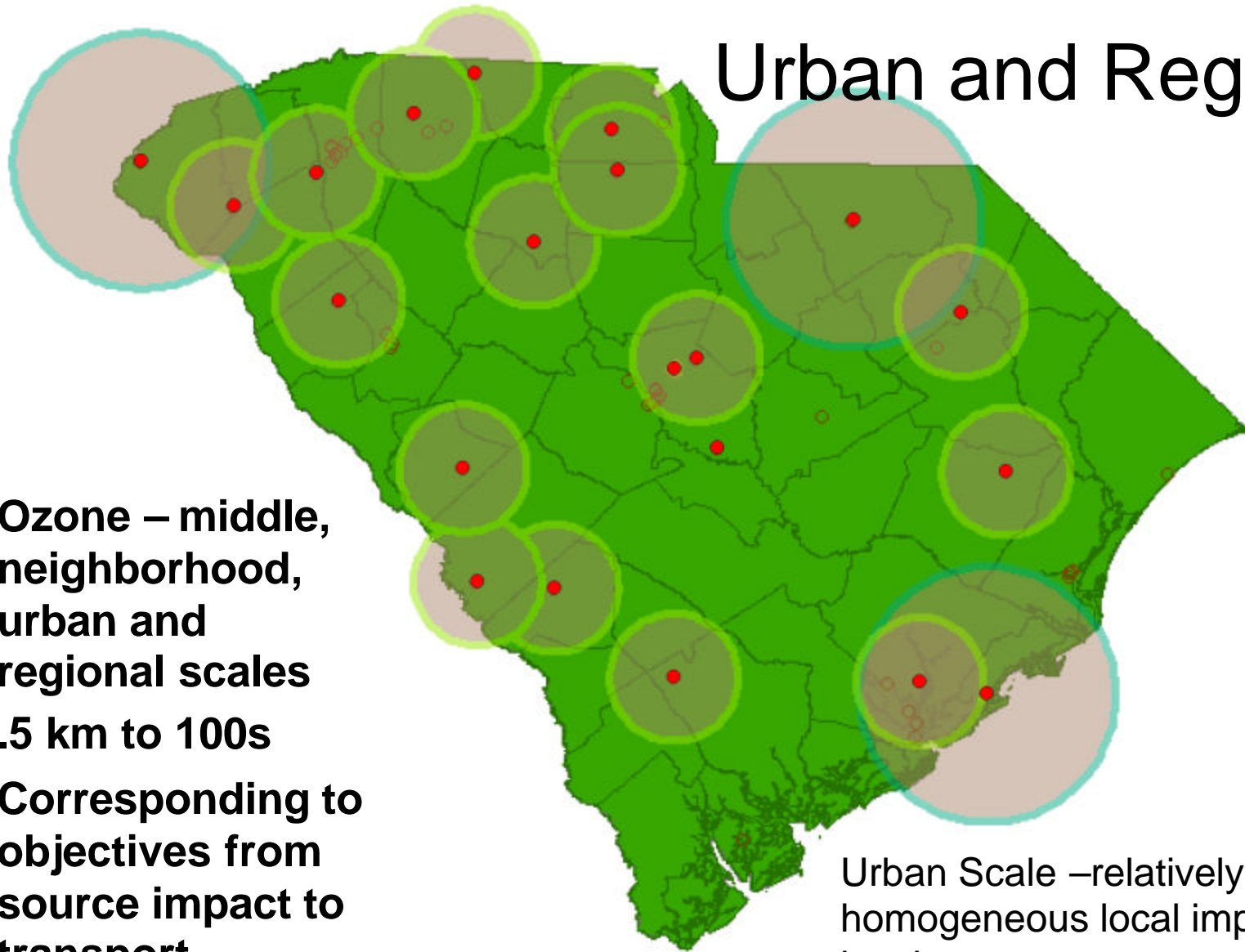
- **Ozone – middle, neighborhood, urban and regional scales**
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Regional Scale –minimal local impacts / local sources

Urban and Regional

- **Ozone – middle, neighborhood, urban and regional scales**
- **.5 km to 100s**
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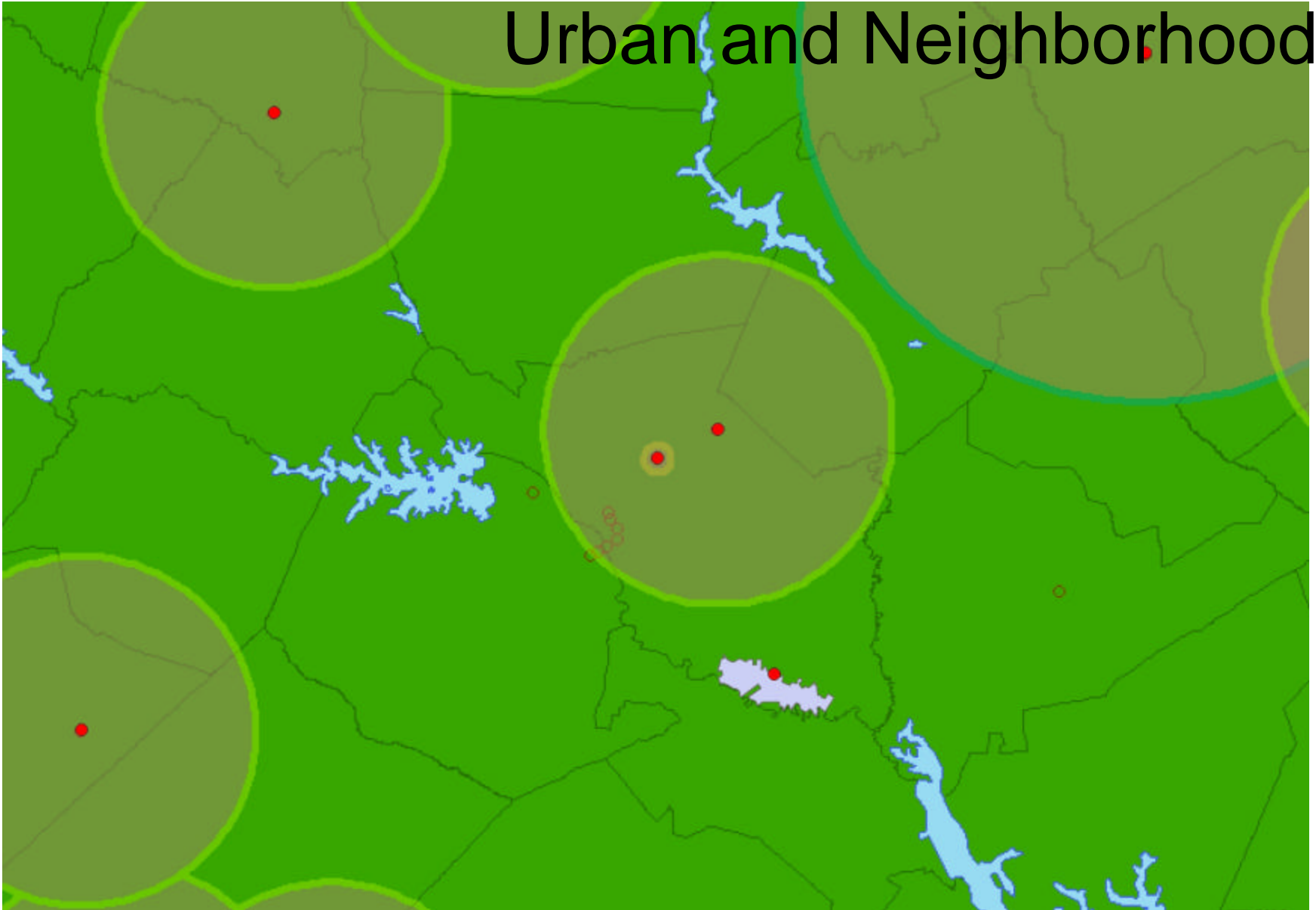


Urban Scale –relatively homogeneous local impacts / local sources

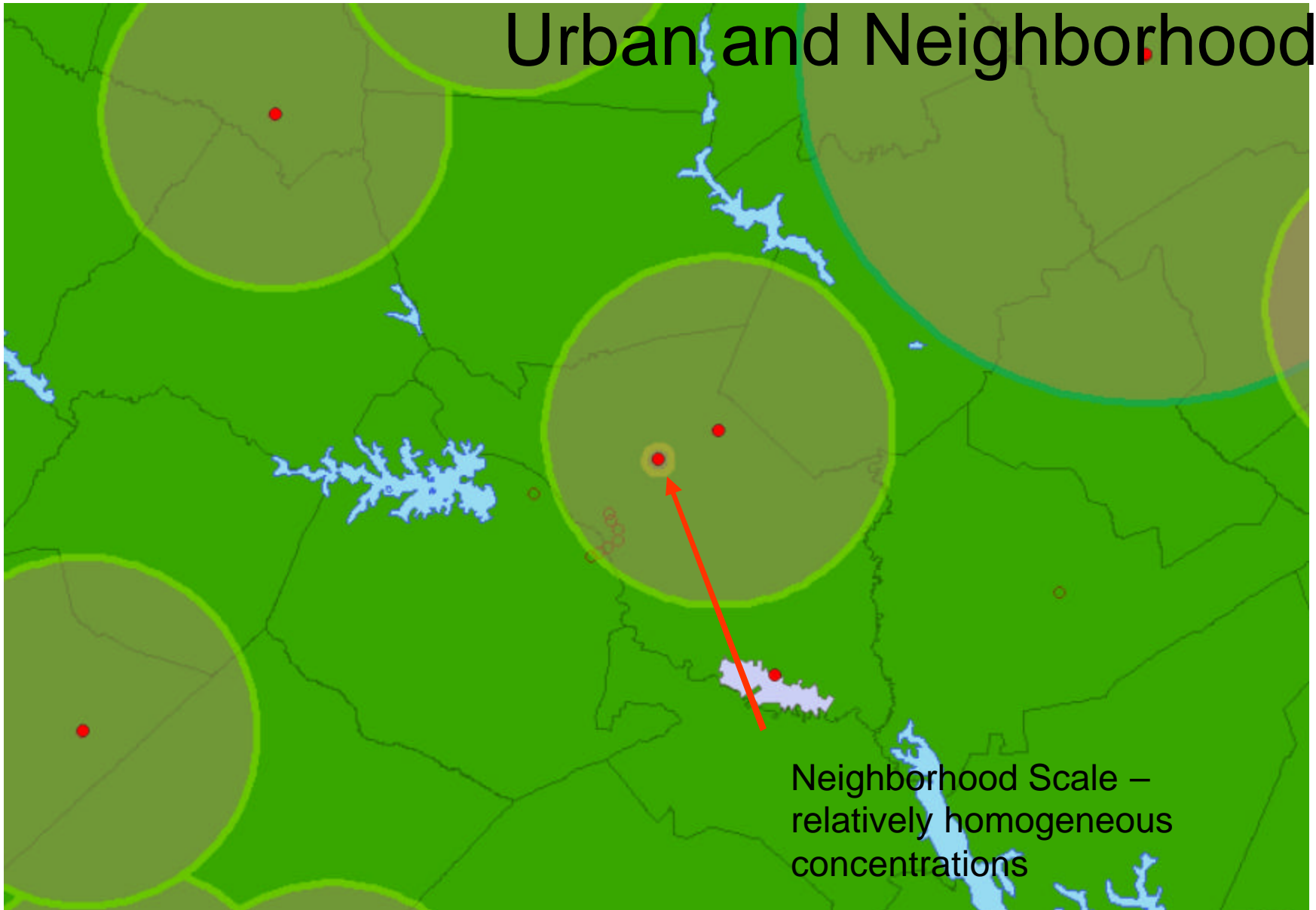
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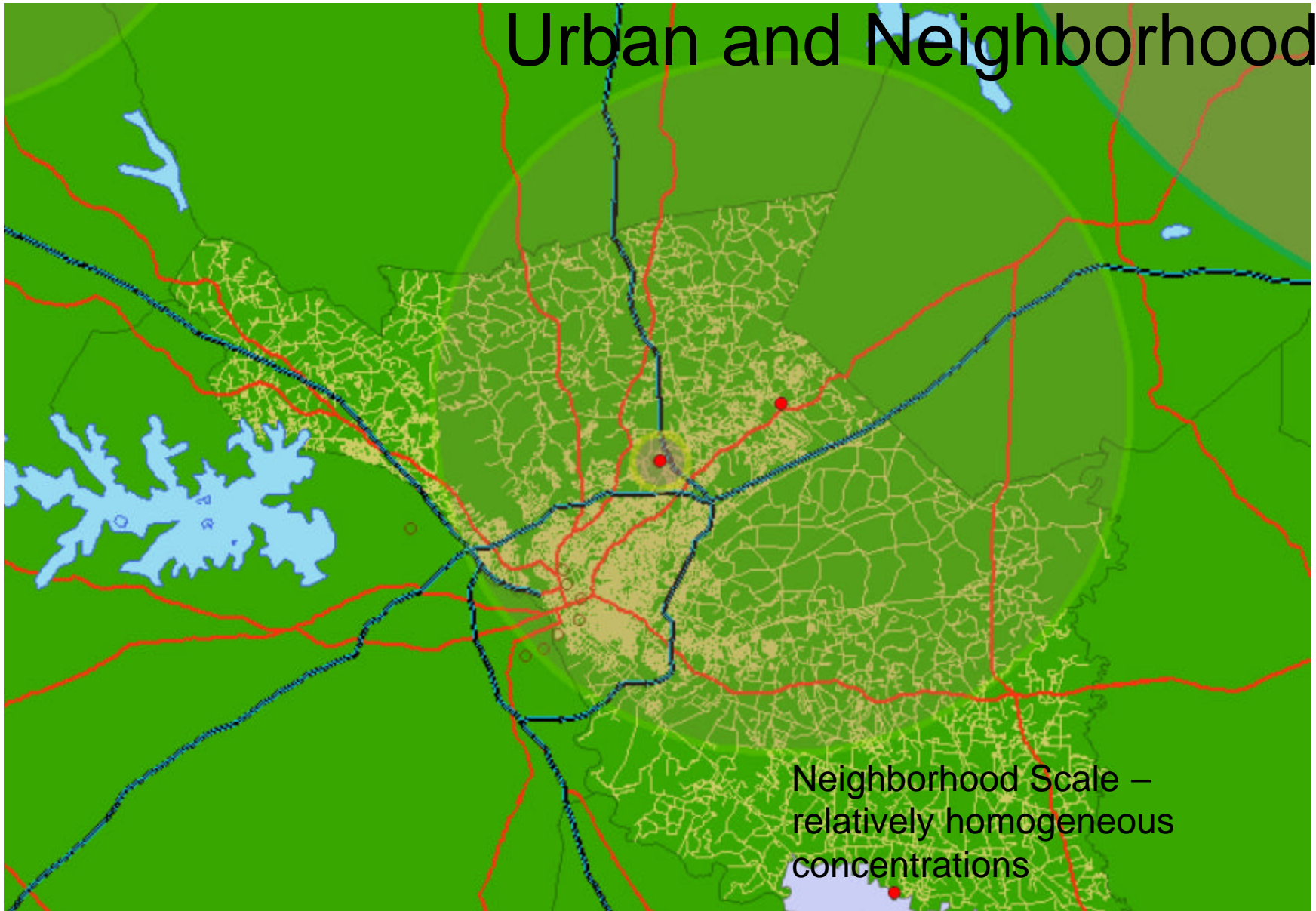
Urban and Neighborhood



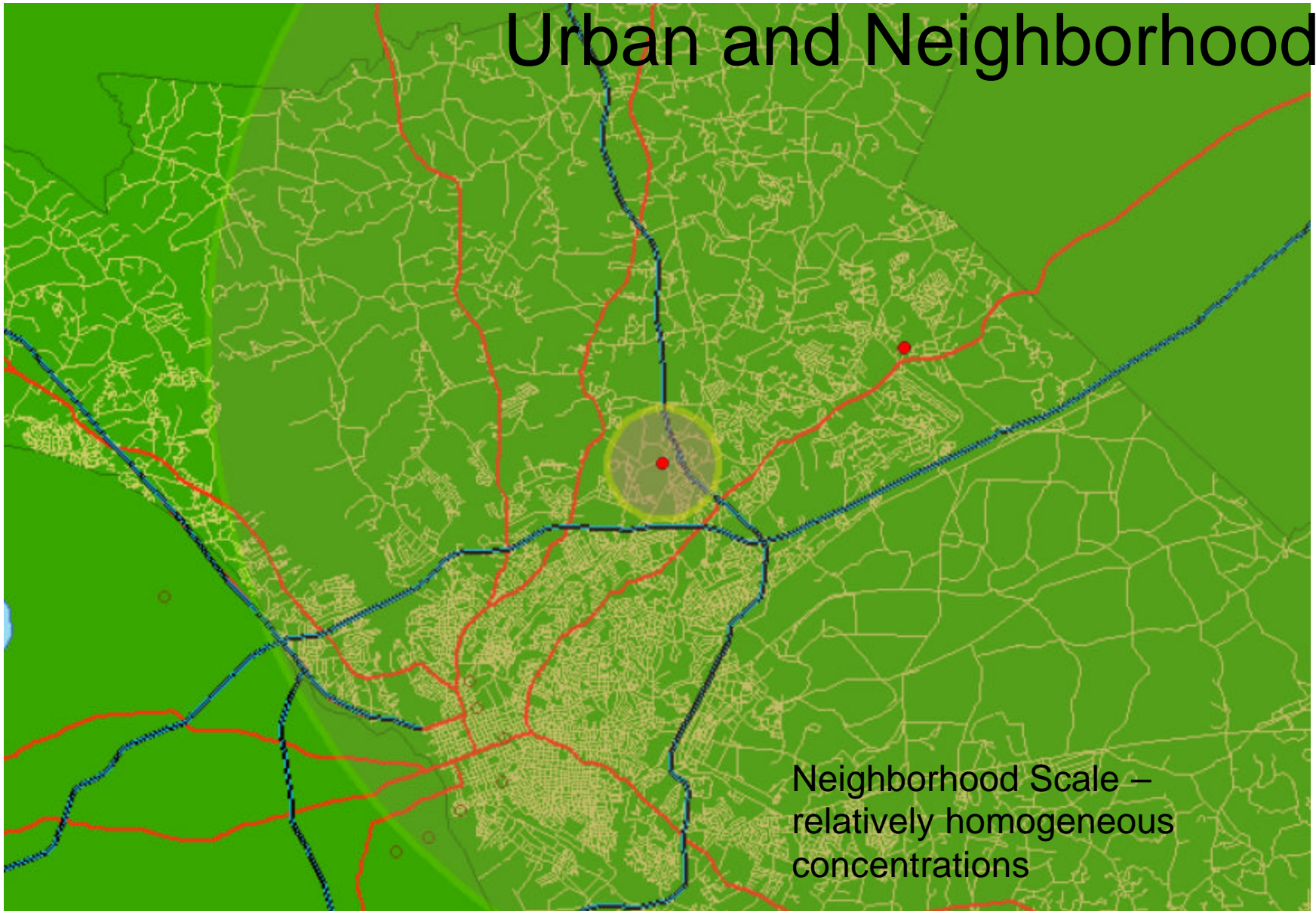
Urban and Neighborhood



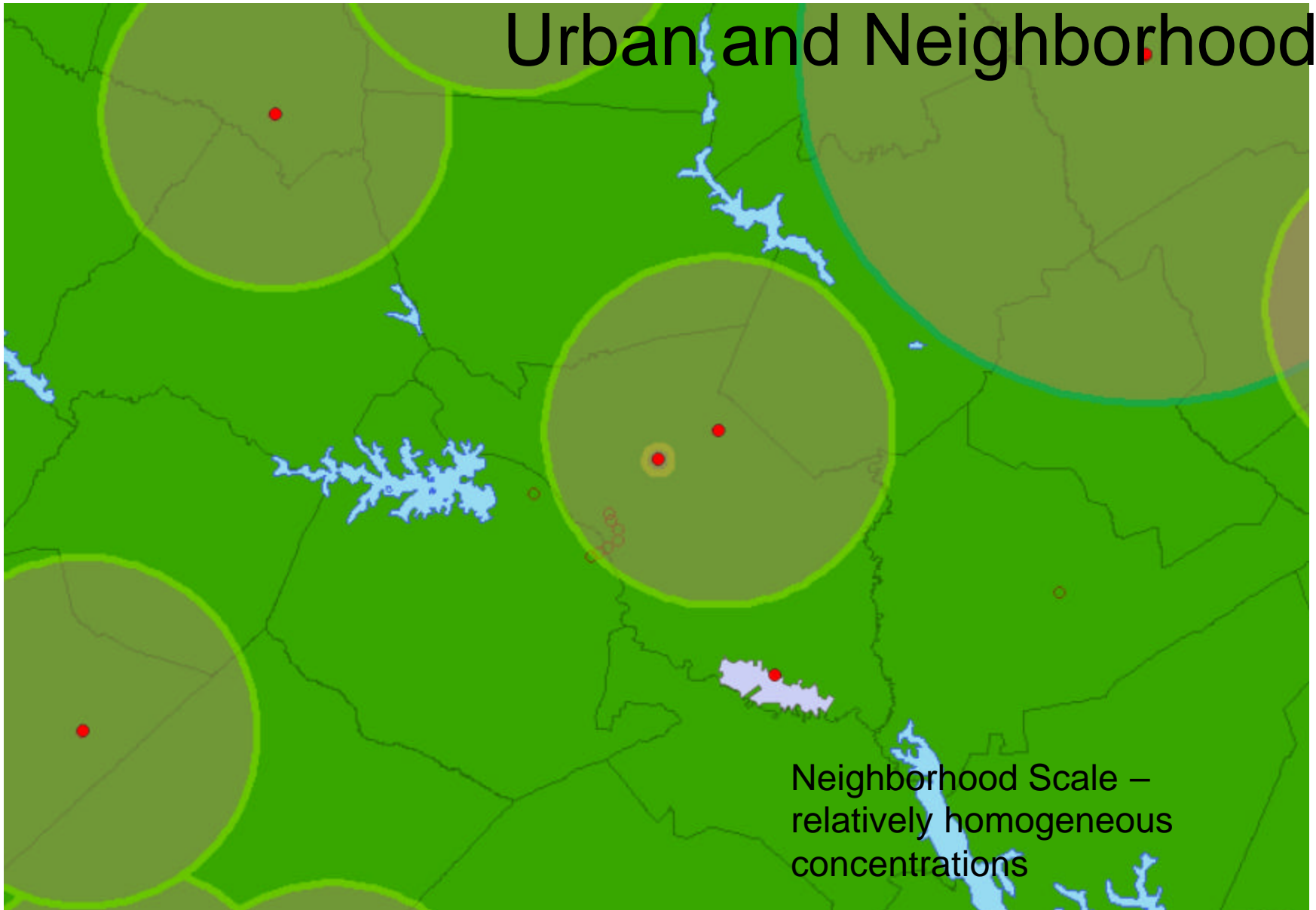
Urban and Neighborhood



Urban and Neighborhood



Urban and Neighborhood



Middle Scale



Middle Scale ?



Micro Scale



Micro Scale



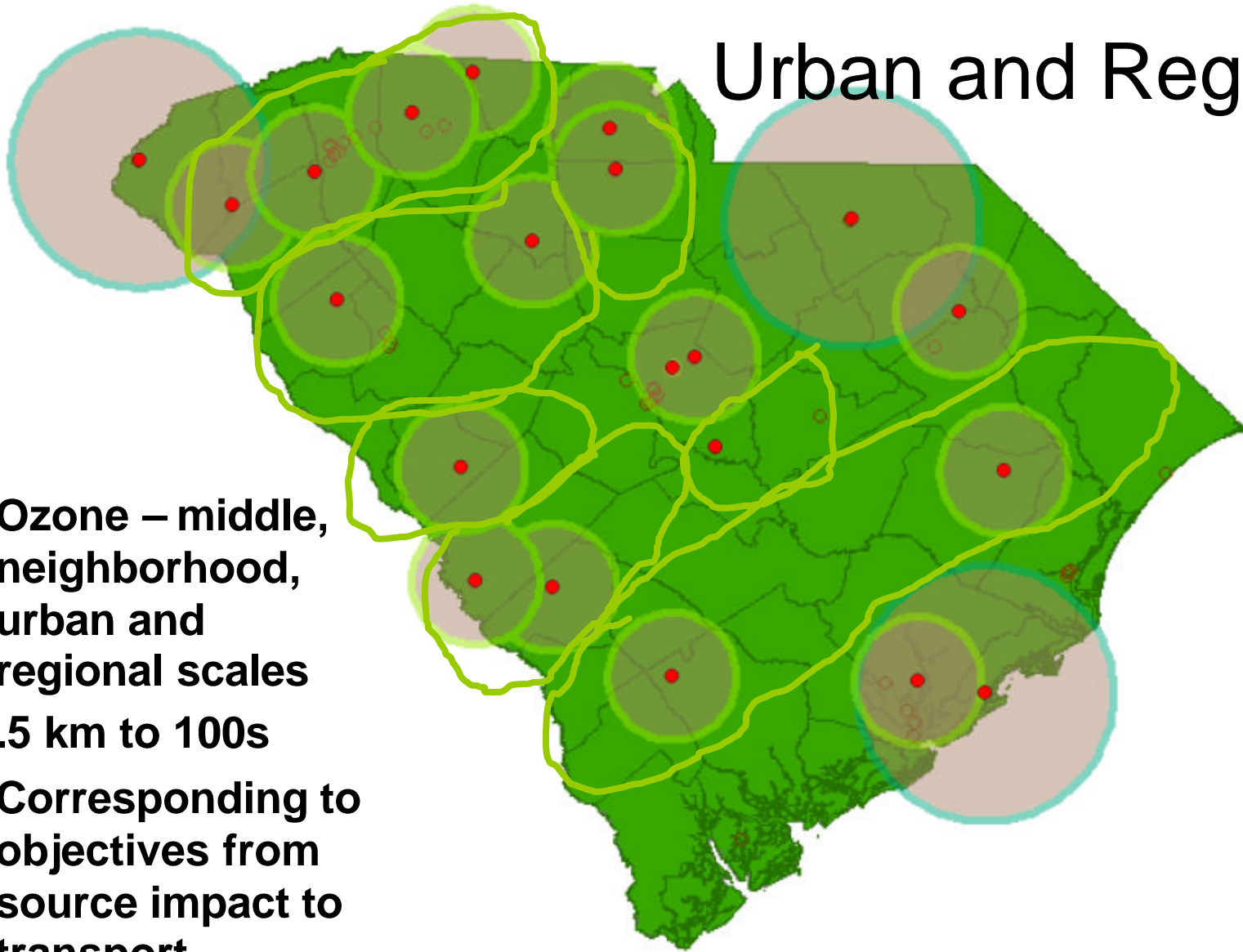
Micro Scale



Micro Scale PM₁₀ –
...maximum concentration
from mobile sources'

Urban and Regional

- **Ozone – middle, neighborhood, urban and regional scales**
- **.5 km to 100s**
- **Corresponding to objectives from source impact to transport**



Urban and Neighborhood

- **Ozone – middle, neighborhood, urban and regional scales**
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Neighborhood Scale –
relatively homogeneous
concentrations

Urban and Neighborhood

- **Ozone – middle, neighborhood, urban and regional scales**
- **.5 km to 100s**
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Neighborhood Scale –
relatively homogeneous
concentrations

Each Objective has appropriate Scales

Table 1 - Relationship Among Monitoring Objectives and Scale of Representativeness

Monitoring Objective	Appropriate Siting Scales
Highest Concentration...	Micro, Middle, Neighborhood (sometimes Urban)
Population.....	Neighborhood, Urban
Source Impact.....	Micro, Middle, Neighborhood
General/background.....	Neighborhood, Urban, Regional
Regional Transport.....	Urban / Regional
Welfare-related impacts.	Urban / Regional

‘..representative...’

‘...the spatial scale of representativeness is described in terms of the physical dimensions of the air parcel nearest to a monitoring station throughout which **actual pollutant concentrations are reasonably similar.**’

‘..representative...’

‘...reasonably similar.’

PM_{2.5}

‘..relatively similar annual average air quality... similar day to day variability.

(average within 20% of area average and correlation greater than about .6)

Spatial Uniformity (PM guidance)

(Annual CV<10% , 20% max deviation)

When evaluating or planning for
'...reasonably'...'relatively'. ...'representative... keep in mind:



When evaluating or planning for

'...reasonably'...'relatively'. ...'representative... **keep in mind:**

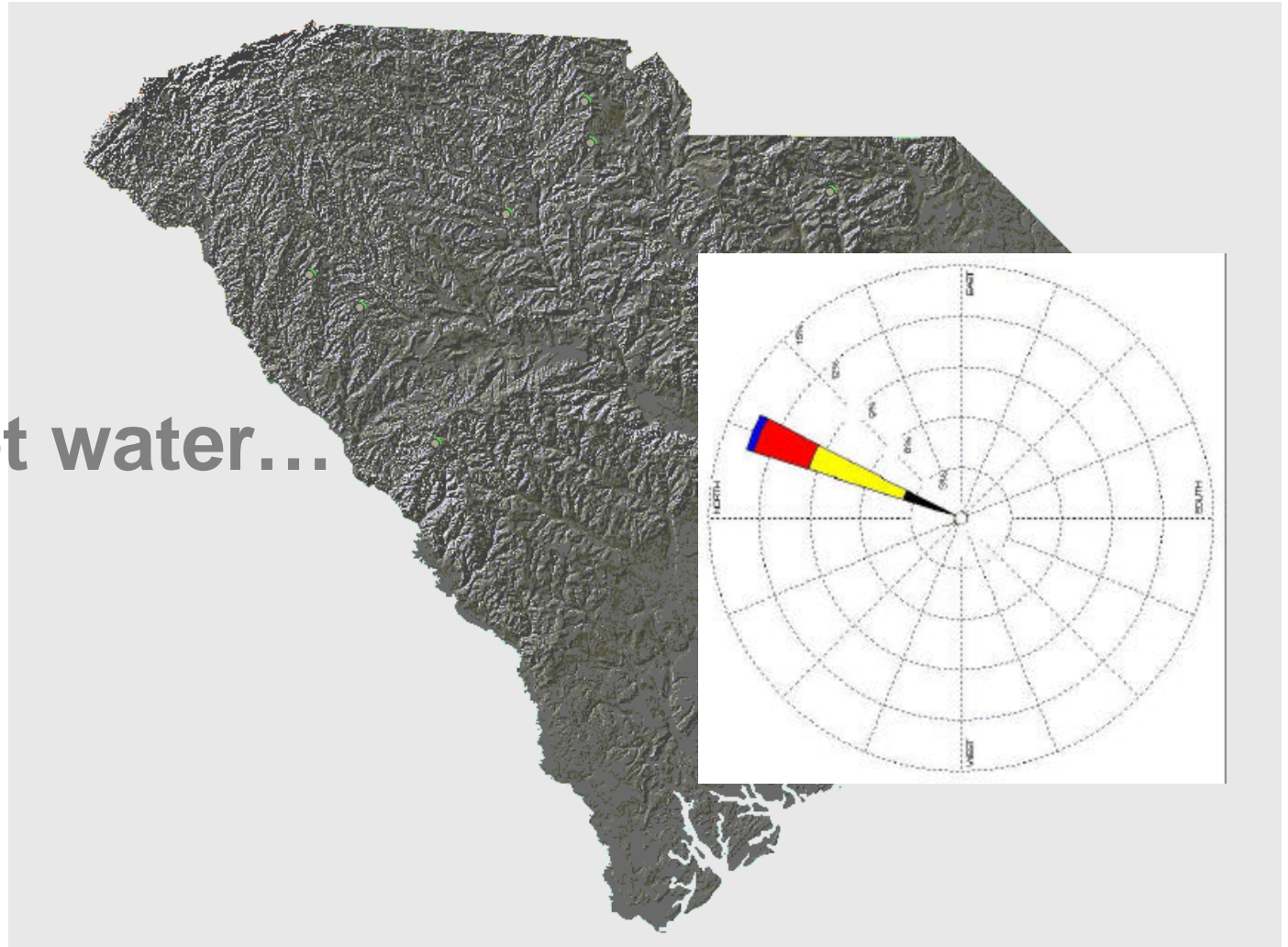
**Topography
matters, but
Air is not water...**



When evaluating or planning for

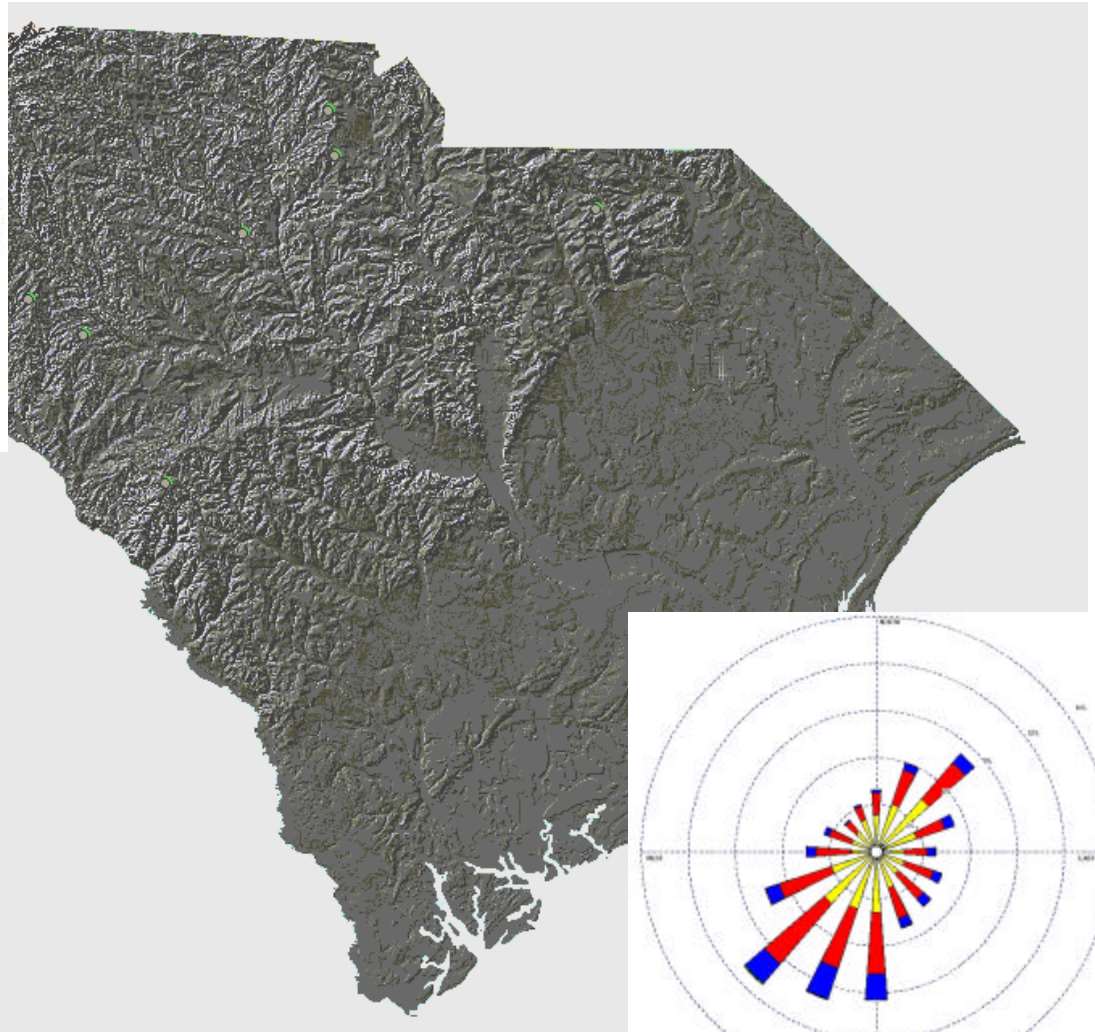
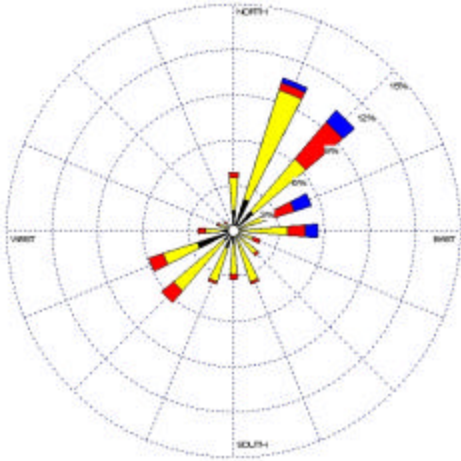
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Air is not water...

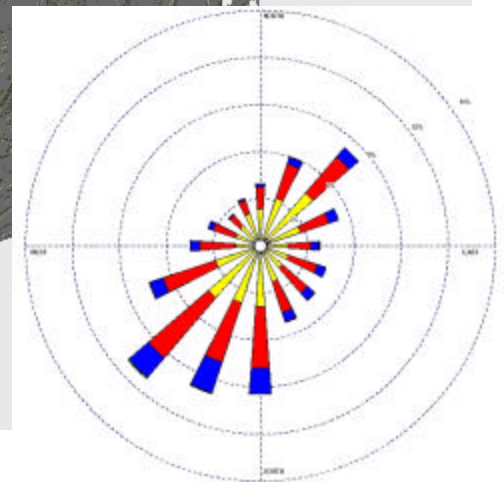


When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

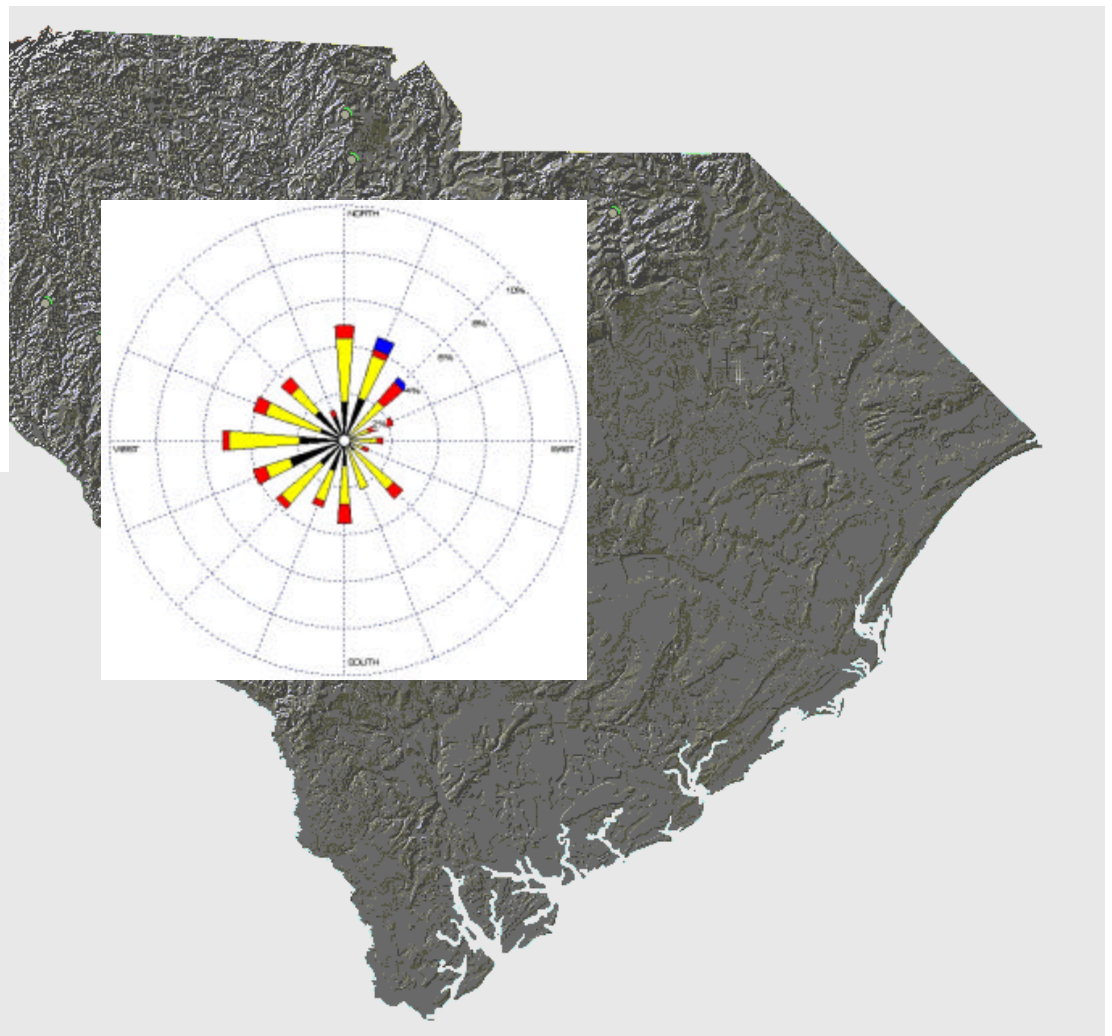
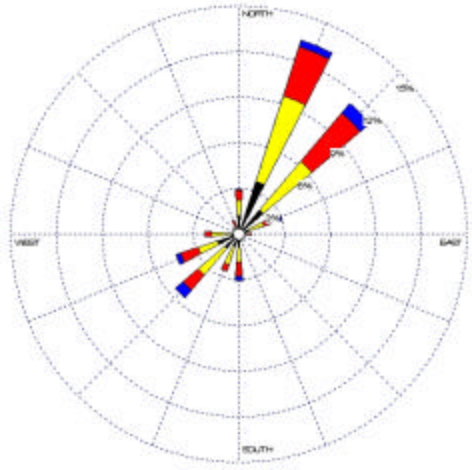


Ozone season



When evaluating or planning for

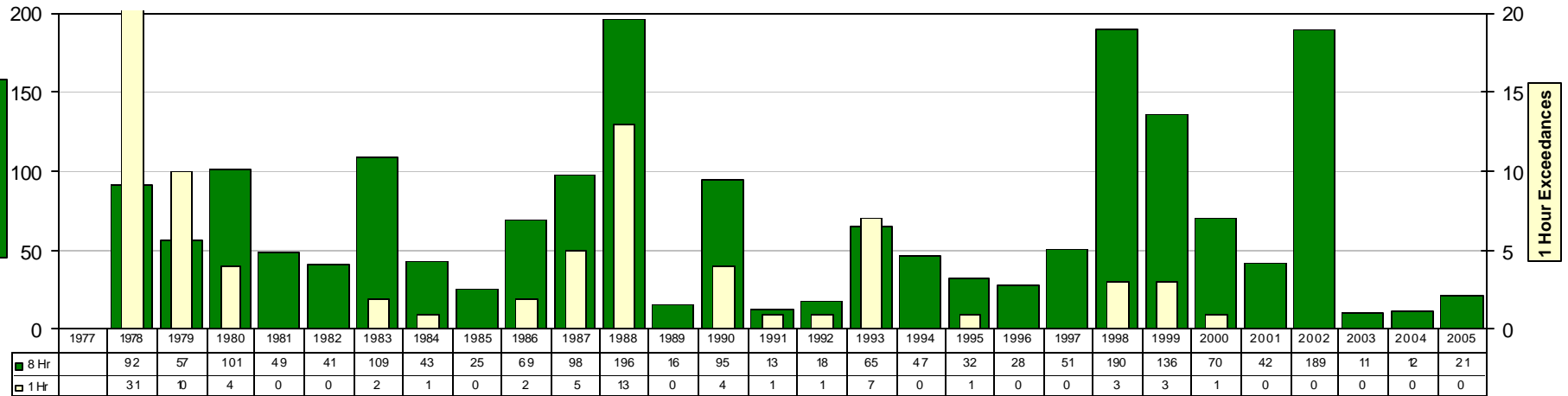
‘...reasonably’...’relatively’. ...’representative... **keep in mind:**



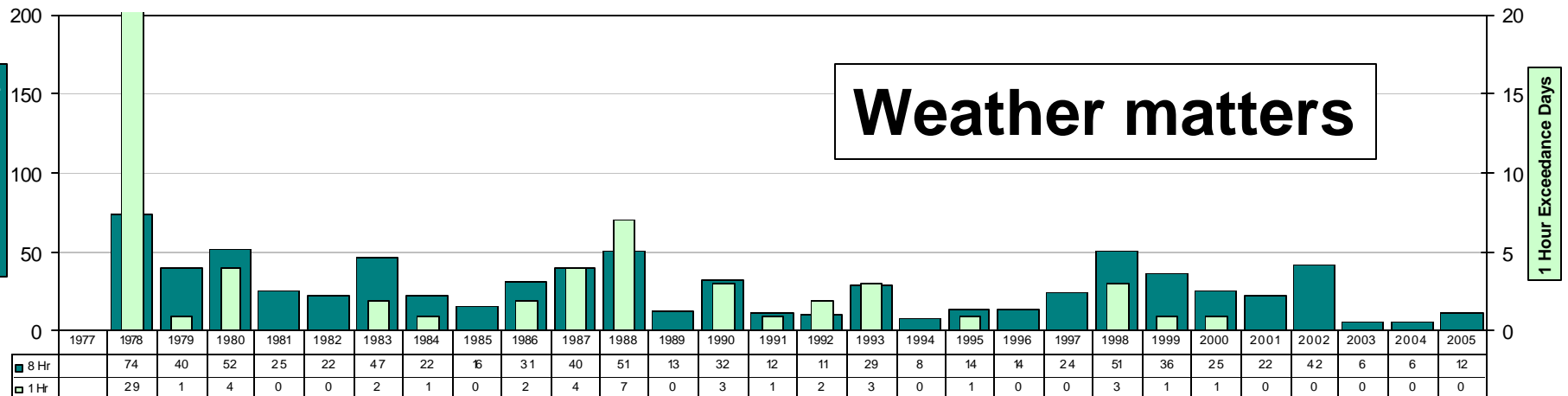
Exceedance days

When evaluating or planning for '...reasonably'...'relatively'. ...'representative... **keep in mind:**

SC Ozone Standard Exceedances

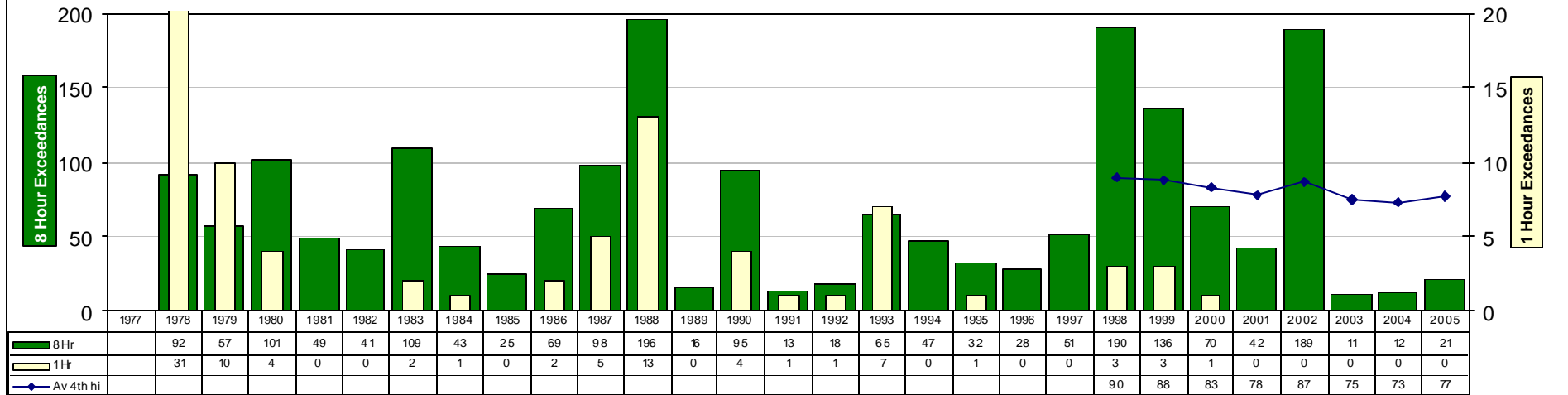


SC Ozone Exceedance Days

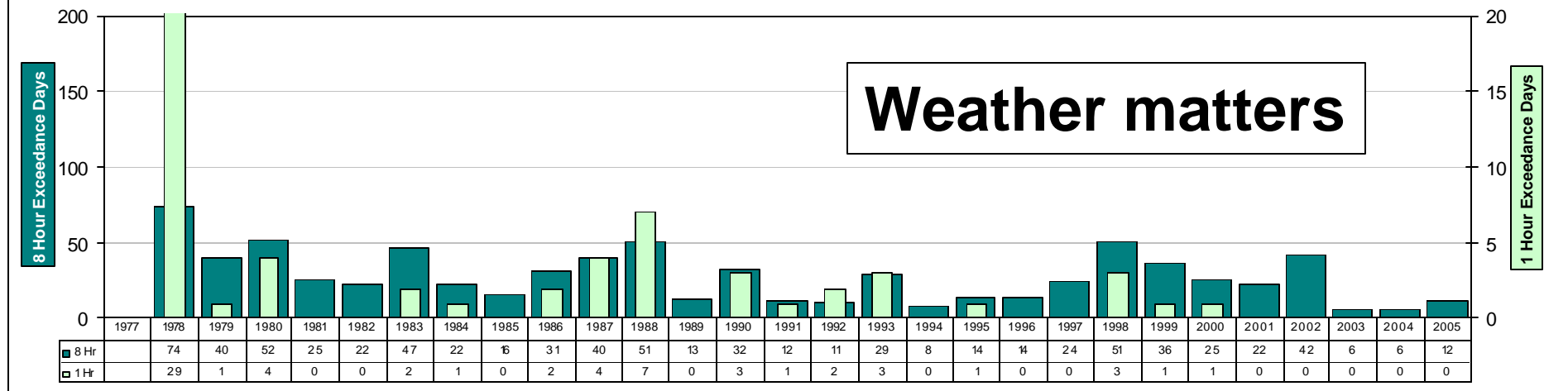


When evaluating or planning for '...reasonably'...'relatively'. ...'representative... keep in mind:

SC Ozone Standard Exceedances



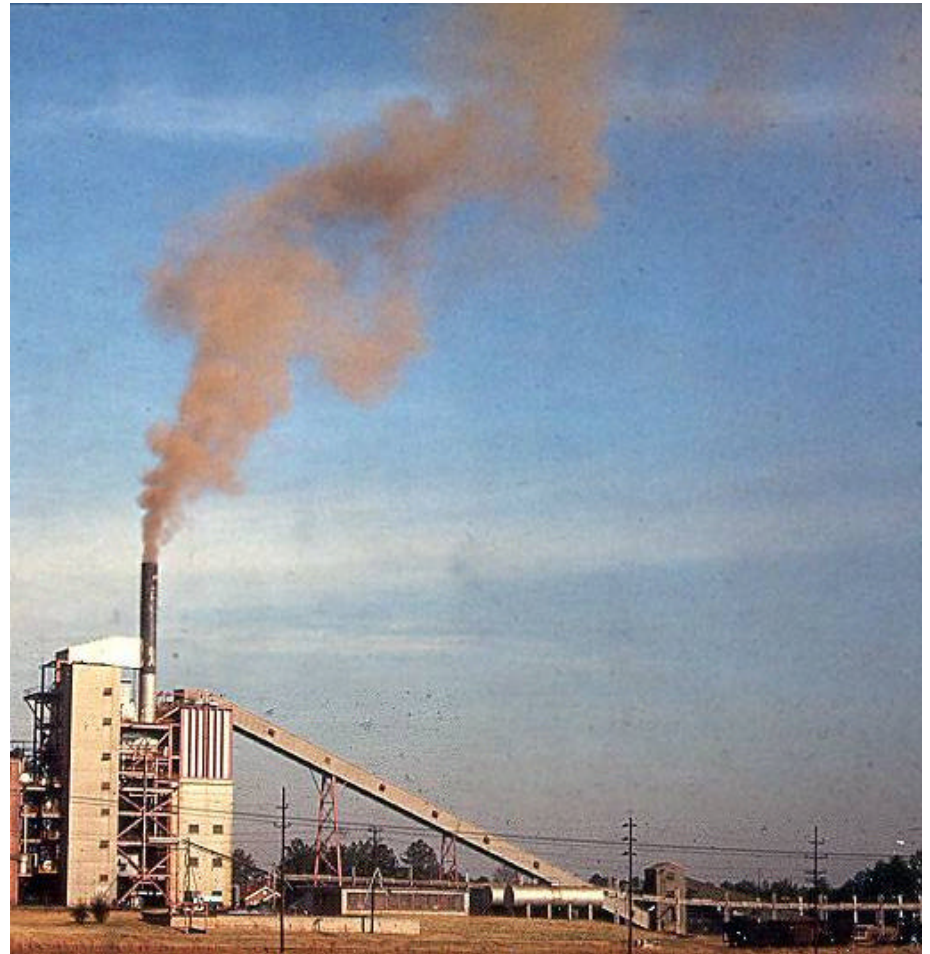
SC Ozone Exceedance Days



When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

**Like water, there
are things that
are in solution
and things that
will settle out.**



When evaluating or planning for

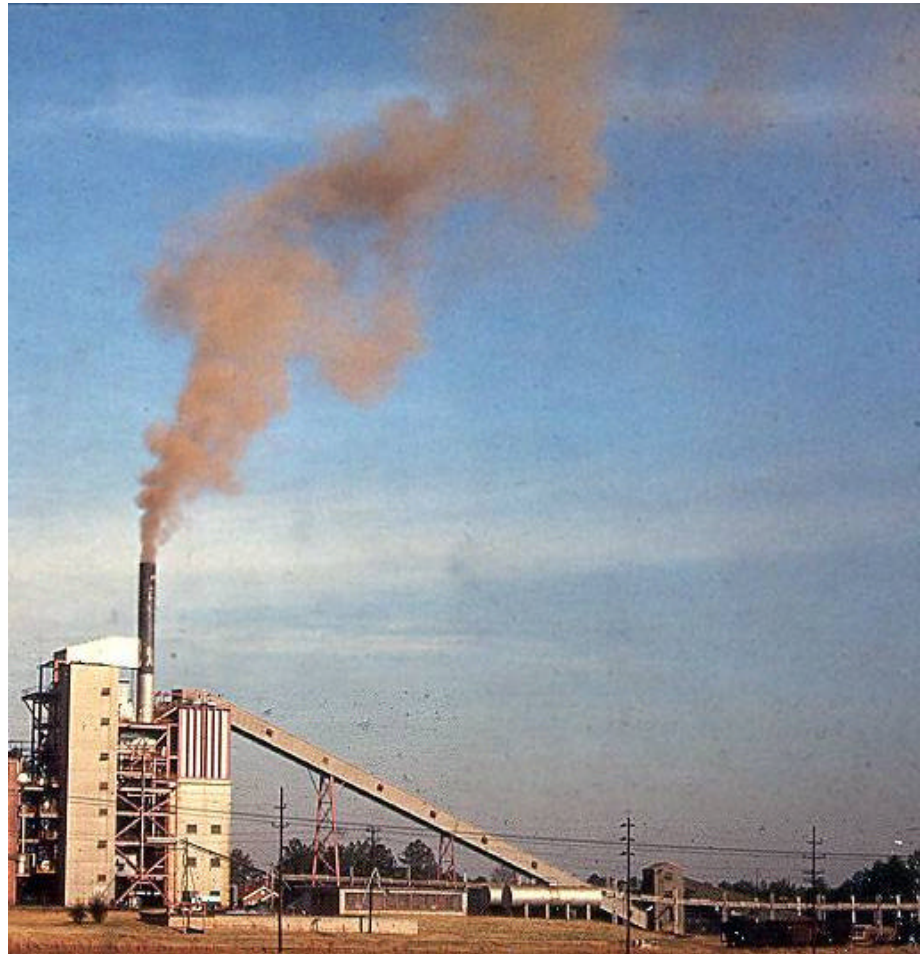
‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

Fewer variables that
affect concentration
are under control

Meteorology

Topography

Distribution (and movement)
of sources



When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

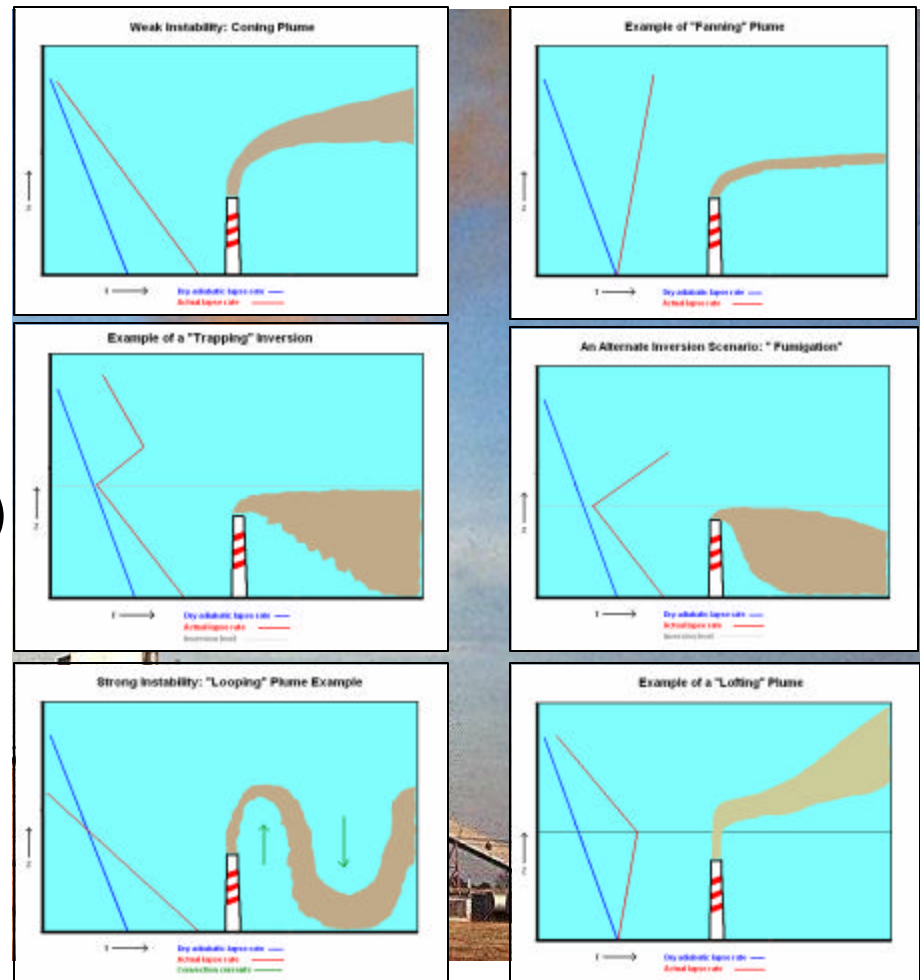
Fewer variables that
affect concentration
are under control

Meteorology

Topography

Distribution (and movement)
of sources

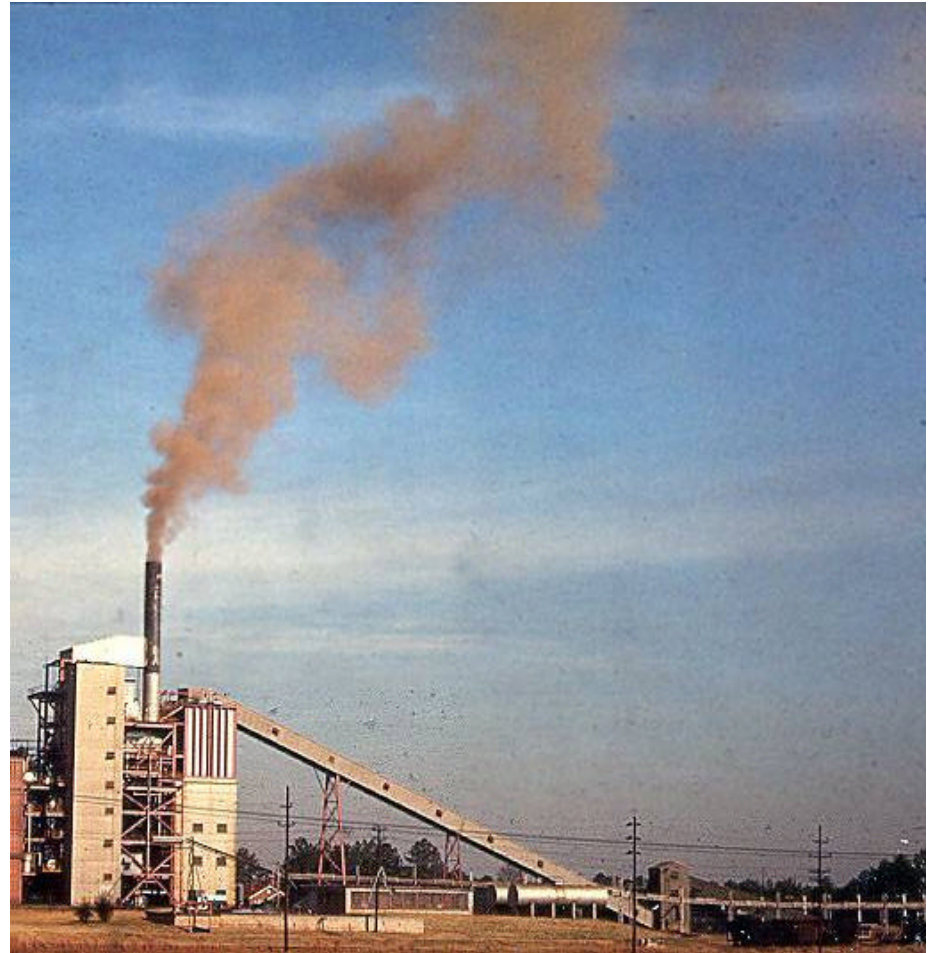
**Local meteorology
can have a BIG
impact**



When evaluating or planning for '...reasonably'...'relatively'. ...'representative... **keep in mind:**

**Sampling period is
important...**

and the appropriate
period and
aggregation depends
on the objective..



When evaluating or planning for '...reasonably'...'relatively'. ...'representative... **keep in mind:**

**Sampling period is
important...**

and the appropriate
period and
aggregation depends
on the objective..

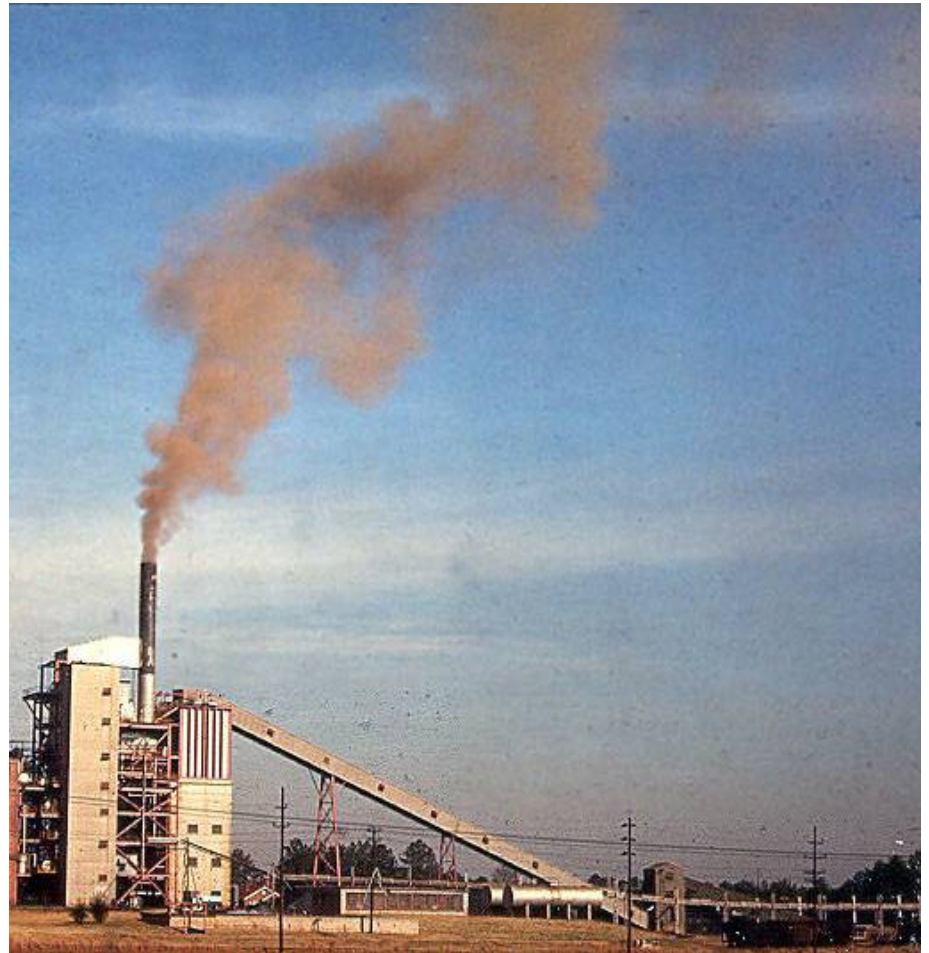


When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

No two sites are identical.

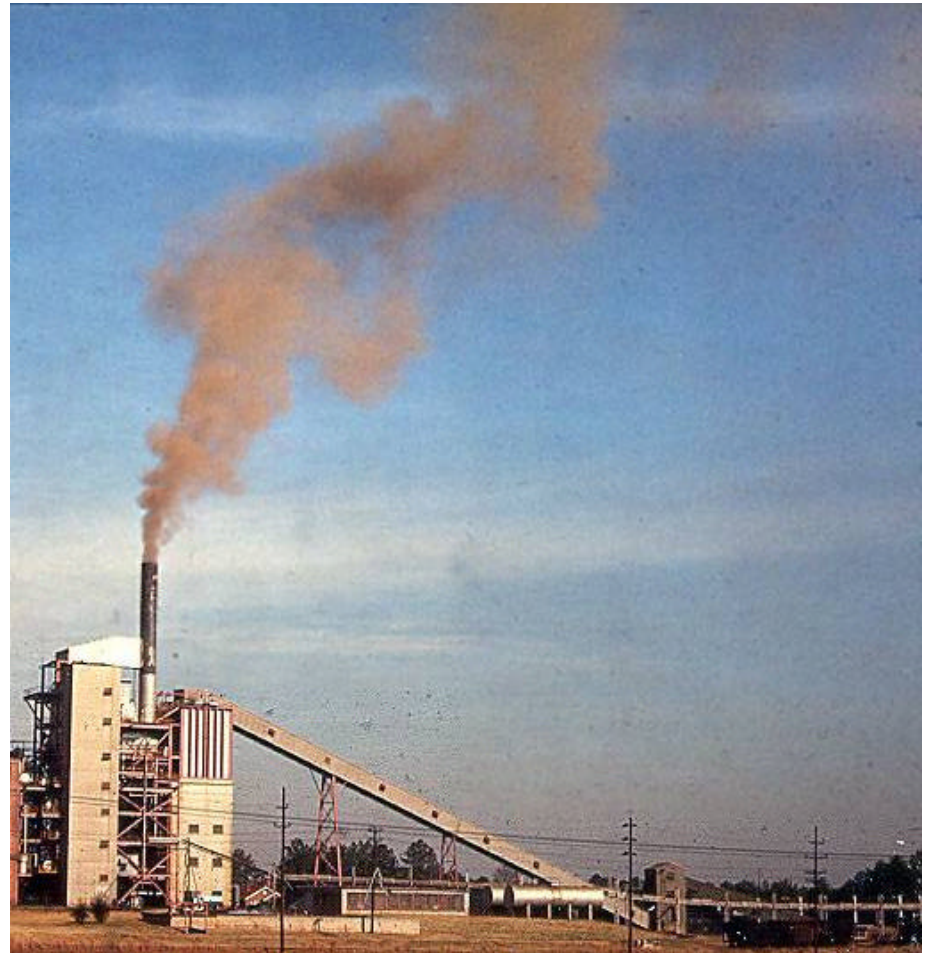
- **Every measurement is a snapshot of that place, at that time...**
...and cannot be redone



When evaluating or planning for '...reasonably'...'relatively'. ...'representative... **keep in mind:**

Every location is impacted by emissions from distant and nearby sources.

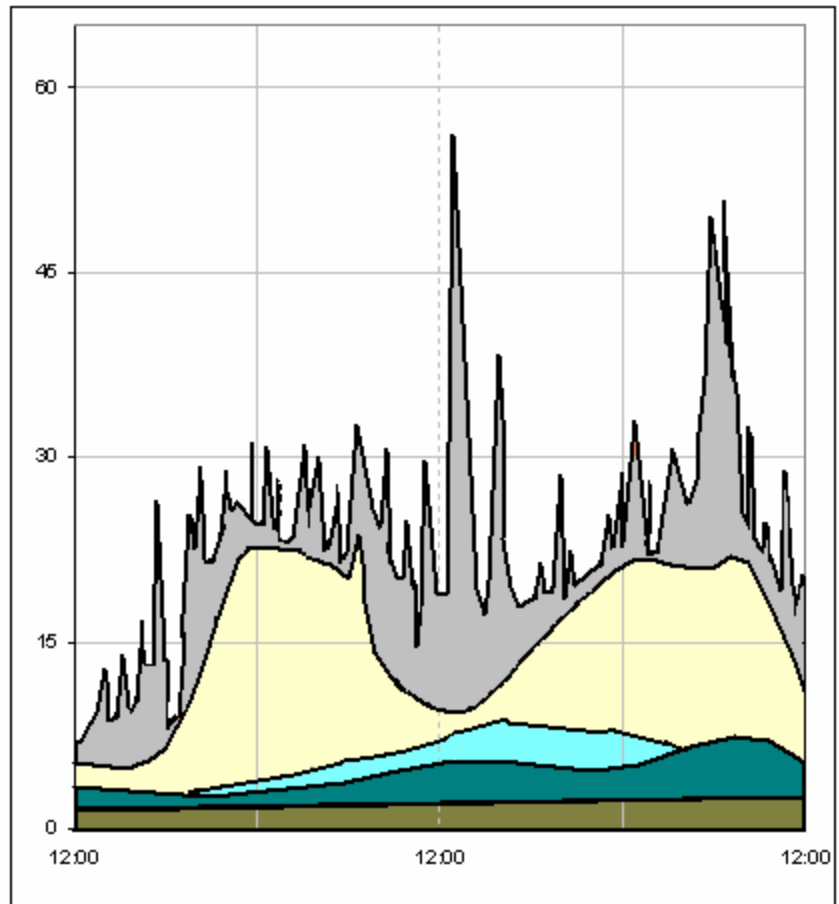
- **The relative contribution can change from minute to minute...**



When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

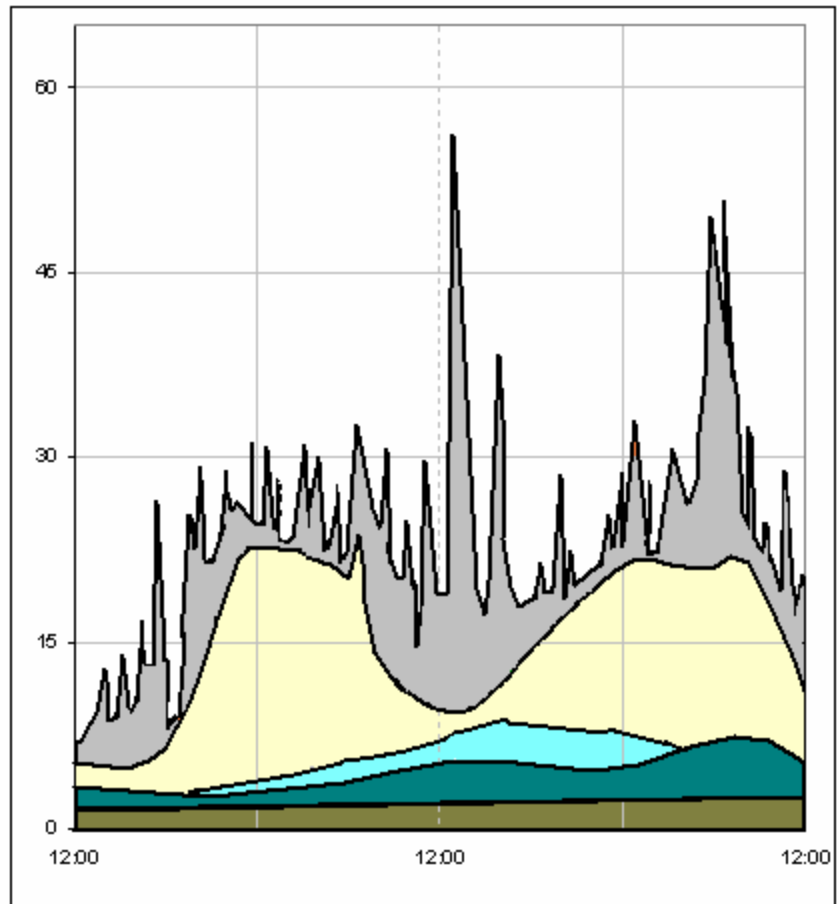
- **The data can provide clues about the impacts at the monitor location.**



When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

- In general, the closer the source(s), the greater the frequency and amplitude of the signal.

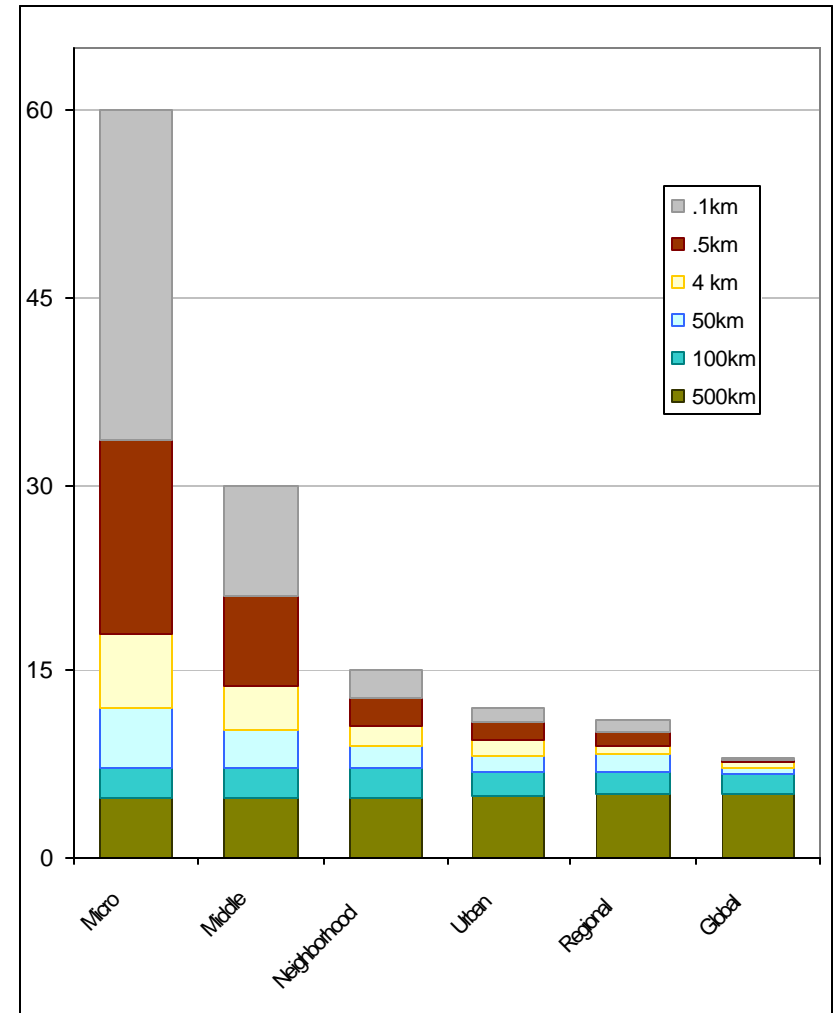


Variability

- The idea of **representative scale** is used to help make sure the balance of impacts on the site match the objective.

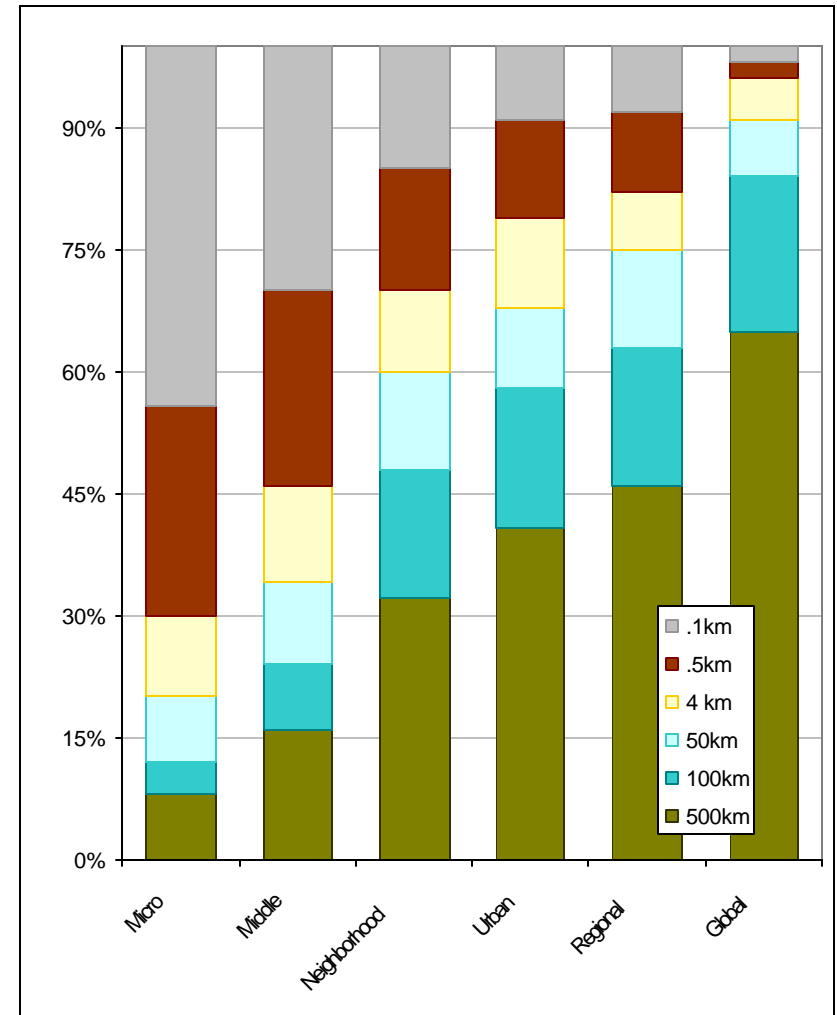
Representative

- The idea of **representative scale** is used to help make sure the balance of impacts on the site match the objective.



Representative

- The idea of **representative scale** is used to help make sure the balance of impacts on the site match the objective.



Spatially and Temporally Representative

- The data needs to be representative both over space and time.

- Averaging periods

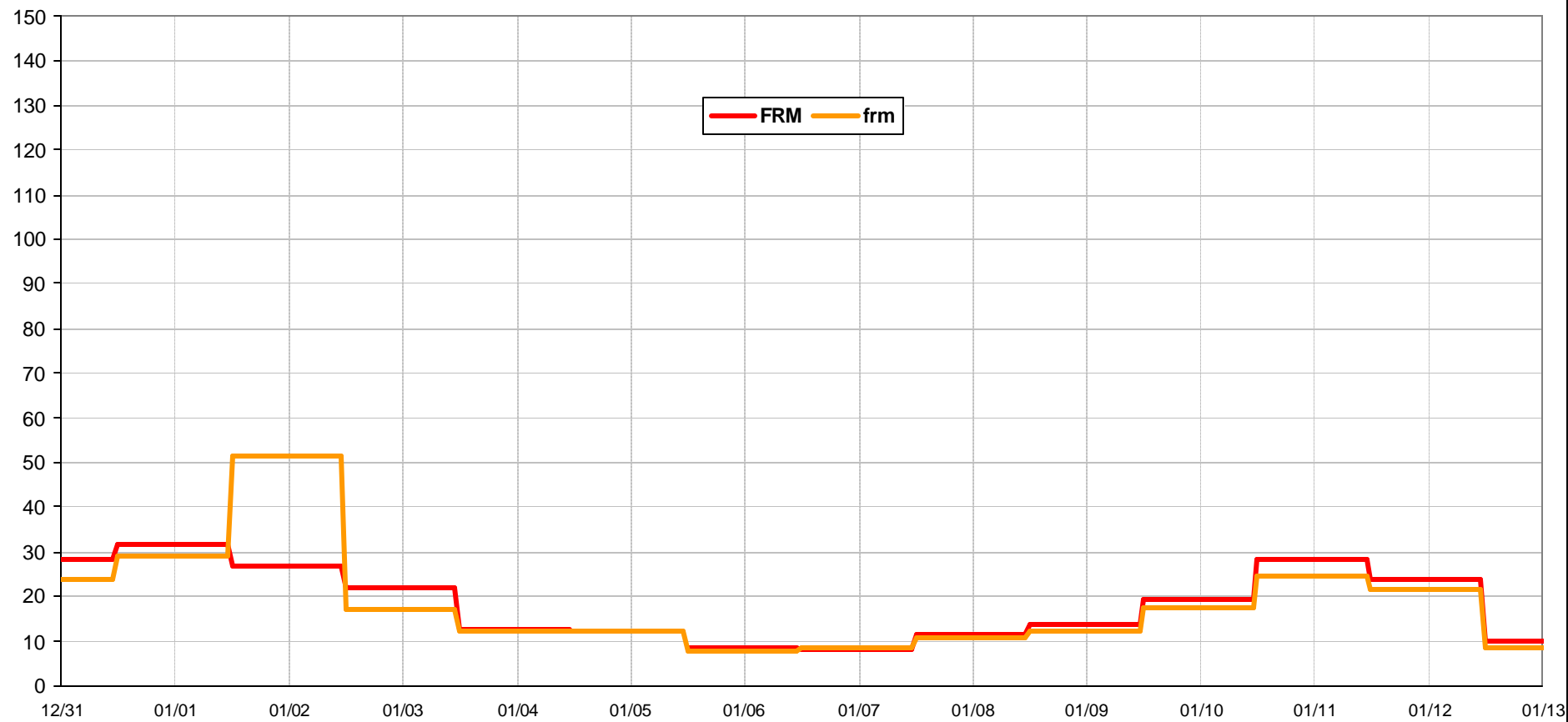
- Multiple sites

- Long path methods



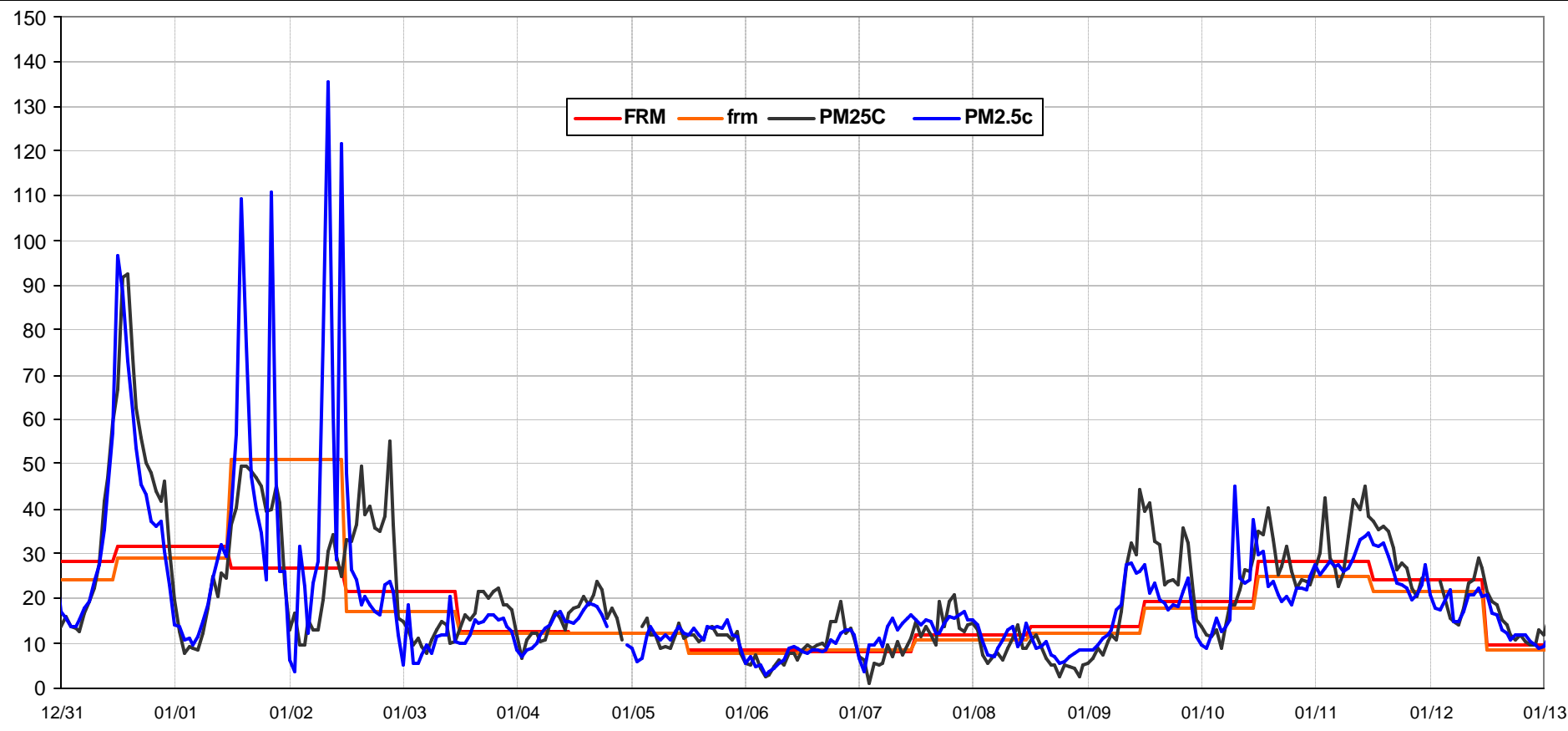
‘...reasonably’...’relatively’...’representative’...

Need to examine long term data

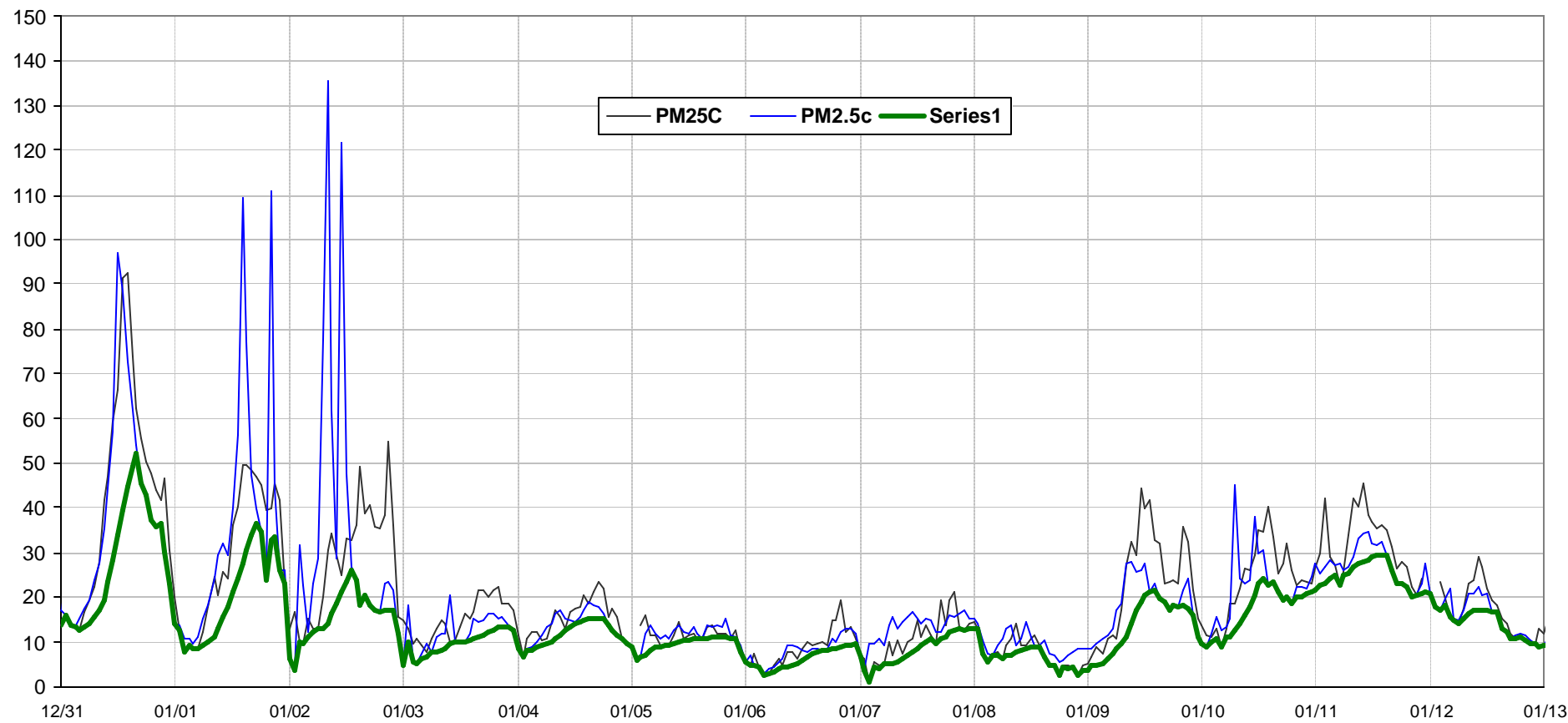


‘...reasonably’...’relatively’...’representative’...

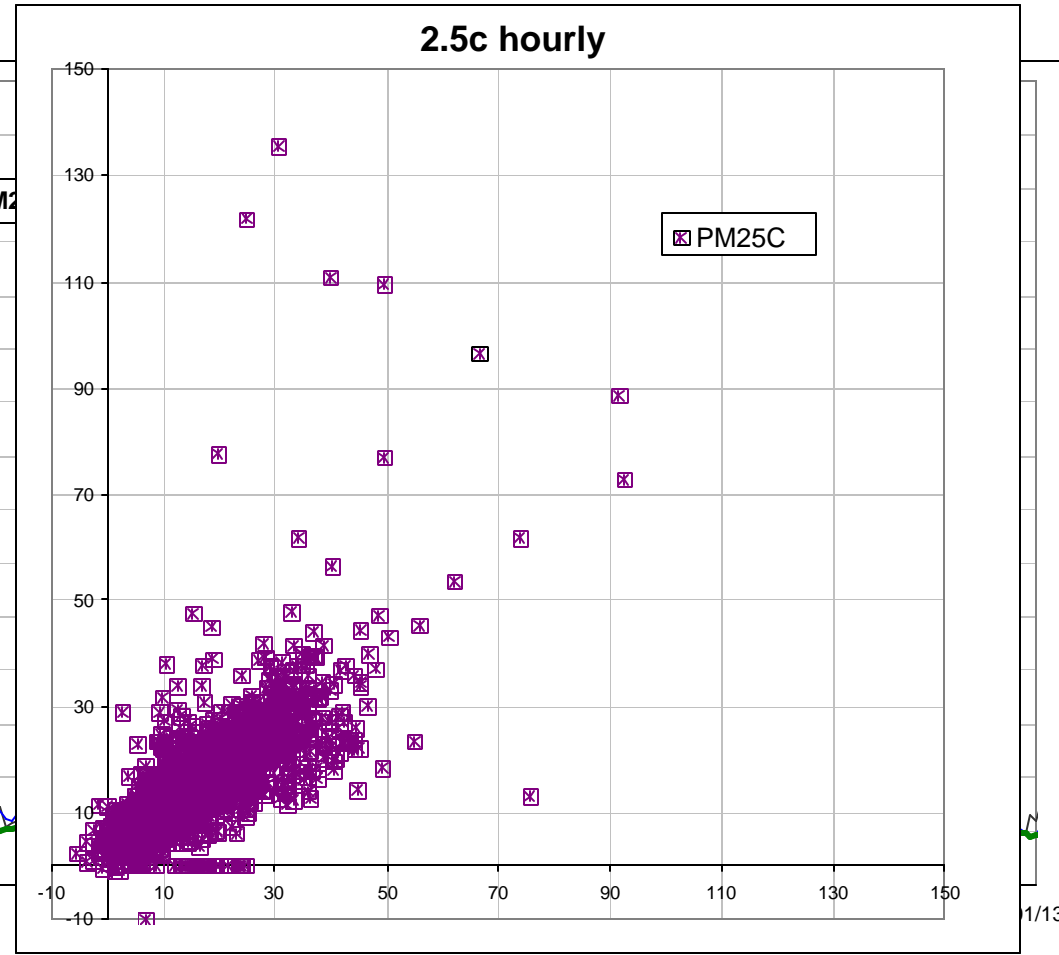
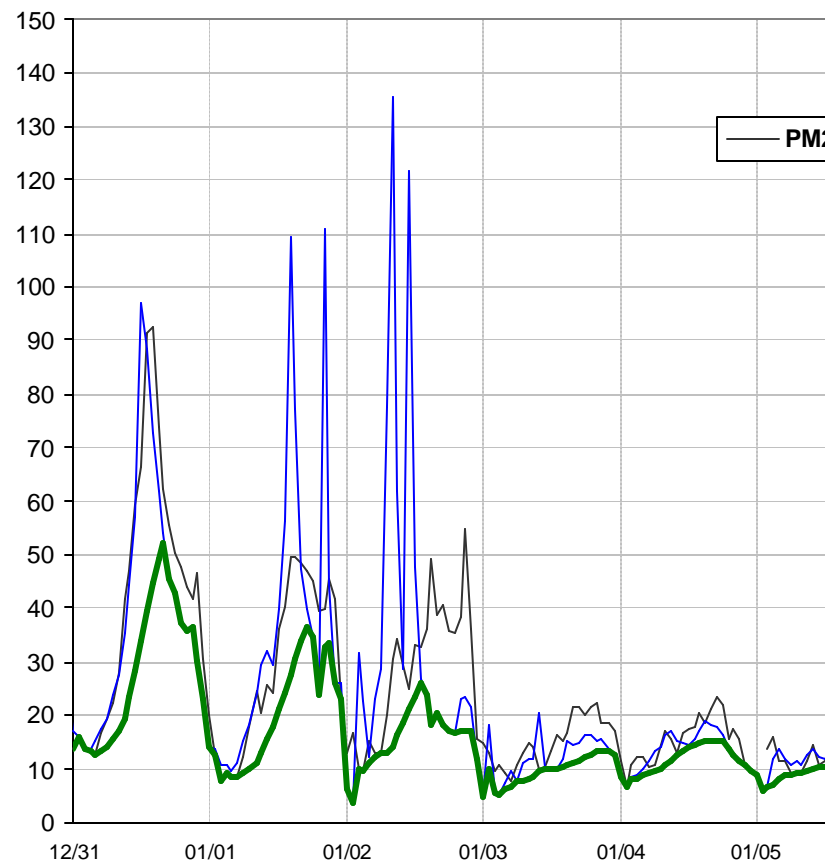
Need to examine long term data



‘...reasonably’...’relatively’...’representative’...
Need to examine long term data

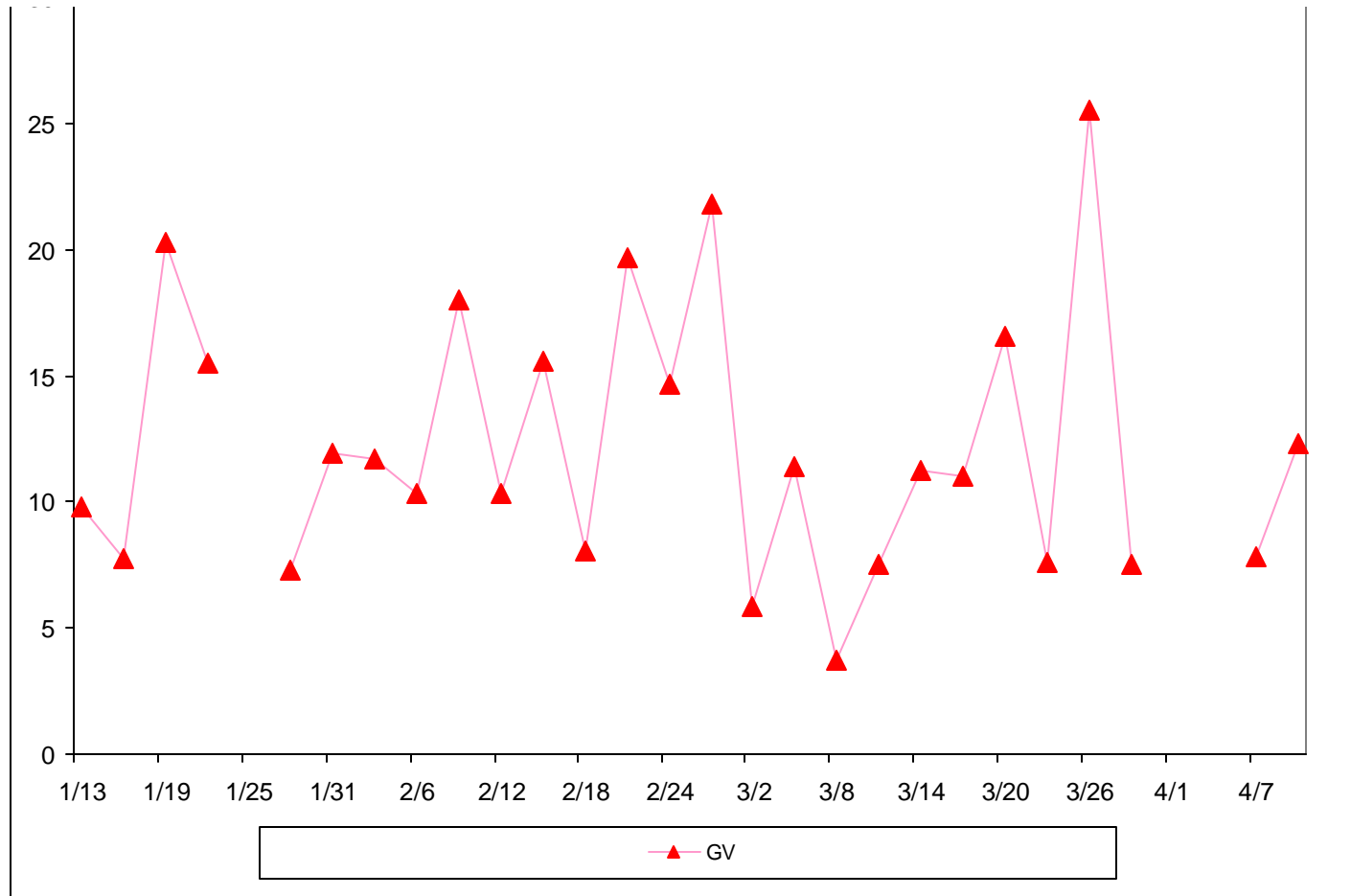


‘...reasonably’...’relatively’...’representative’...
Variability happens...



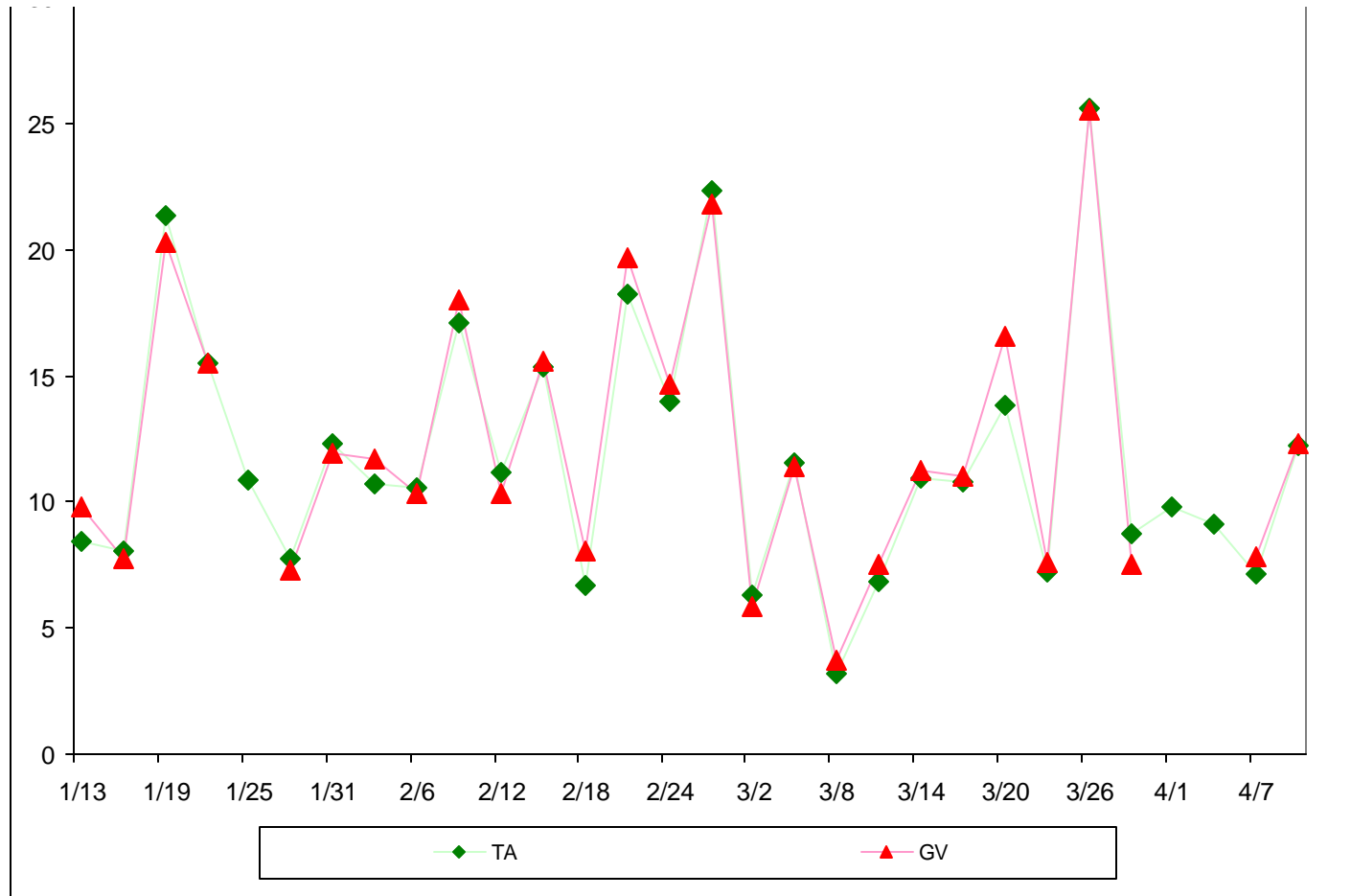
‘...reasonably’...’relatively’...’representative’...

Need to test assumptions



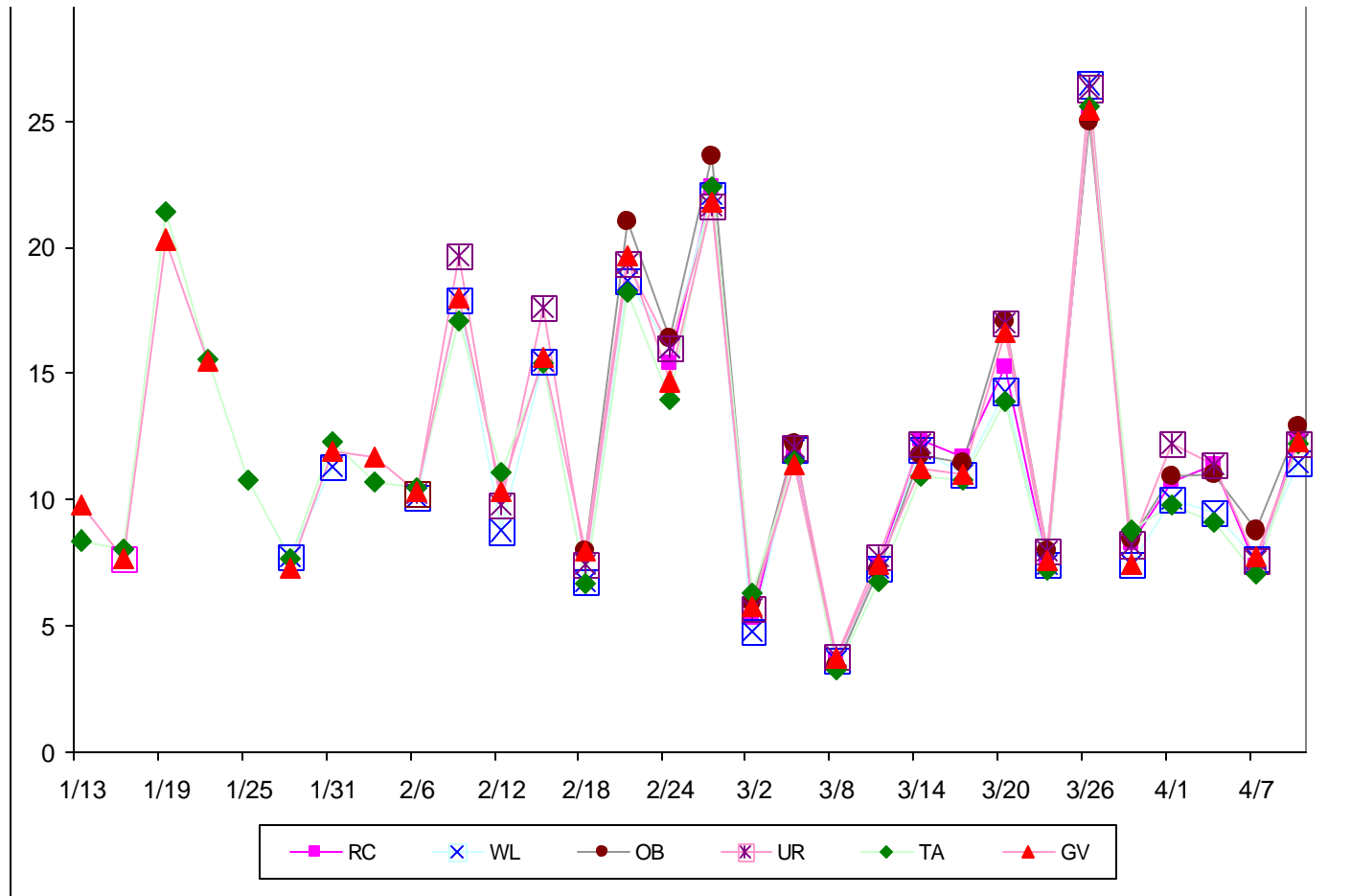
‘...reasonably’...’relatively’...’representative’...

Need to test assumptions

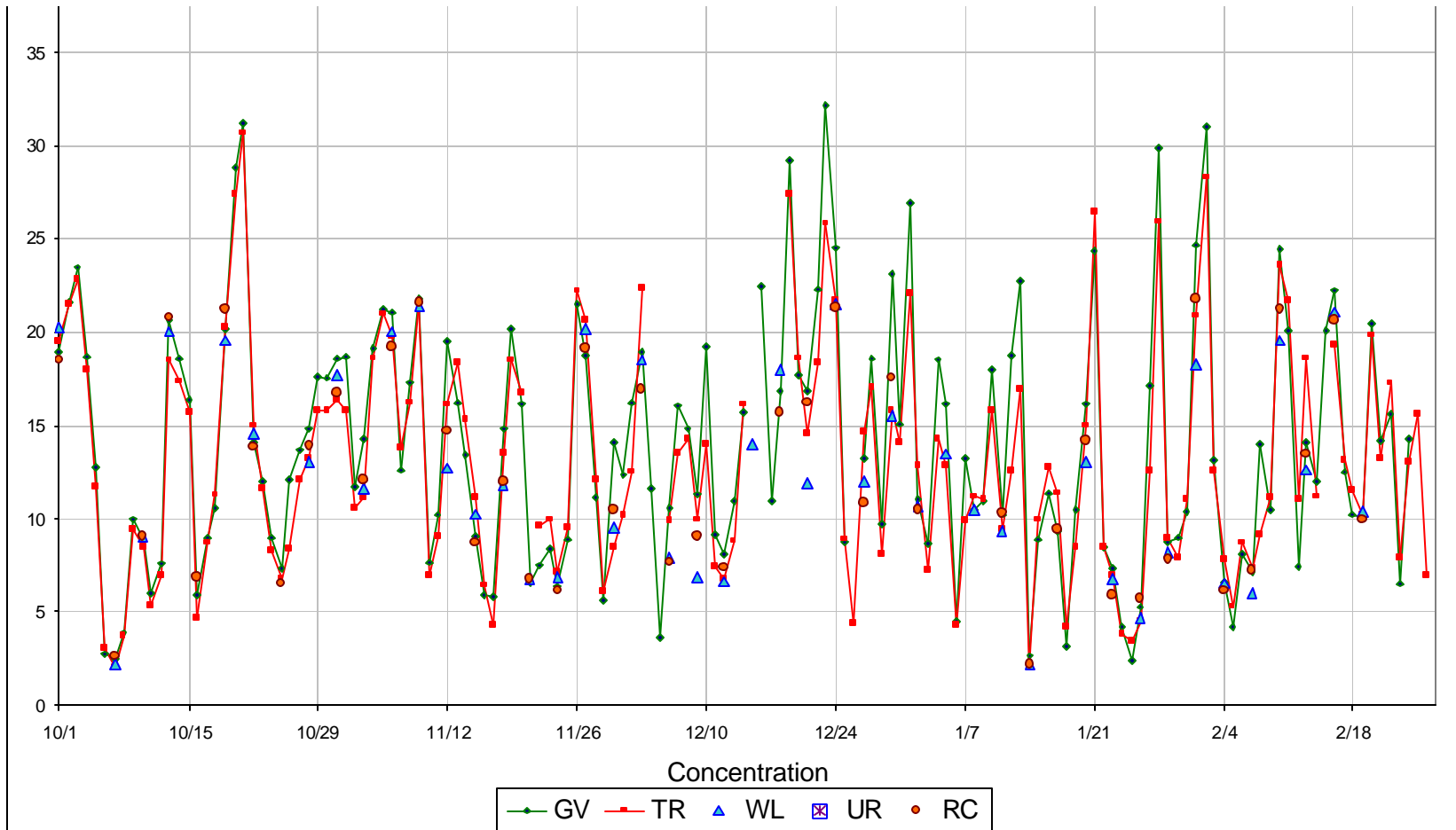


‘...reasonably’...’relatively’...’representative’...

Need to test assumptions



‘...reasonably’...’relatively’...’representative’...
(and possibly retest...)



‘...reasonably’...’relatively’...’representative...

Need to test **all** assumptions.

TSP used 1:6 day sampling:

- ~65 samples a year
- ‘unbiased’ system
- every day of the week sampled equally
- consistent nationwide
- practical

‘...reasonably’...’relatively’...’representative...

Need to test **all** assumptions.

PM_{2.5} needed more samples to meet the data quality objectives of the national program – 1:3 ?:

- ~130 samples a year
- ‘unbiased’ system
- every day of the week sampled equally
- consistent nationwide
- practical

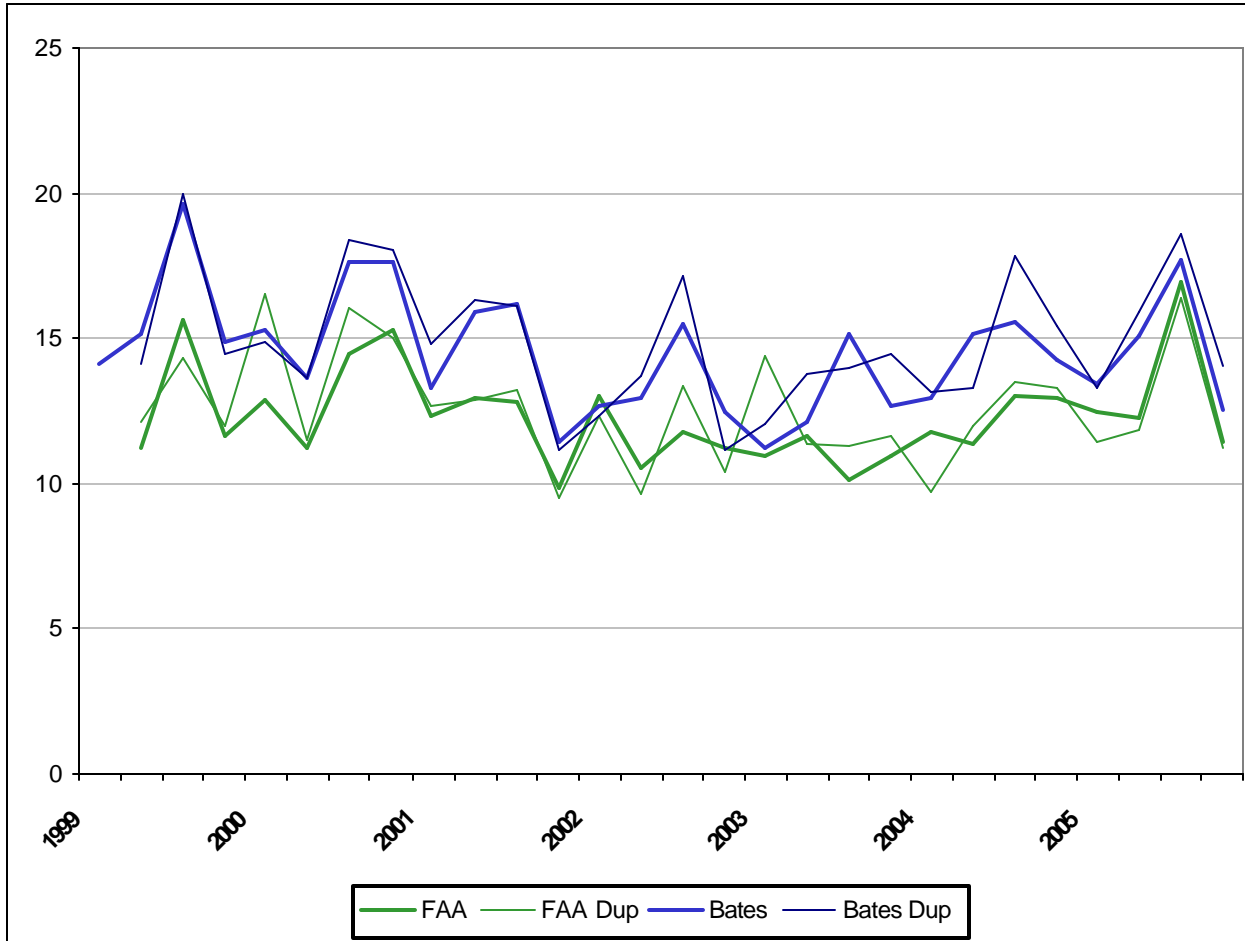
‘...reasonably’...’relatively’...’representative...’

Need to test **all** assumptions.

PM_{2.5} core samplers sampled 1:1 with a collocated sampler at 1:6 for QA.

- quarterly averages of collocated samplers more different than the precision would suggest.

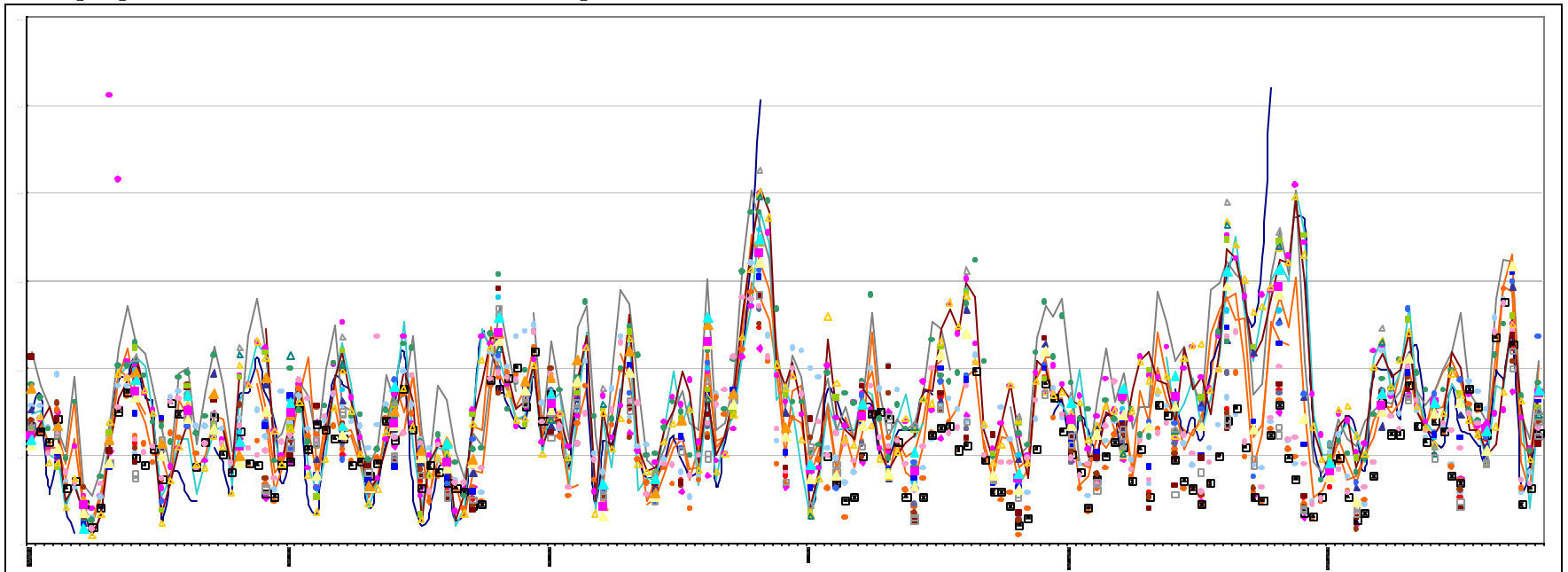
‘...reasonably’...’relatively’...’representative’...
Need to test **all** assumptions.



Hmmm...

‘...reasonably’...’relatively’...’representative’...
Need to test **all** assumptions.

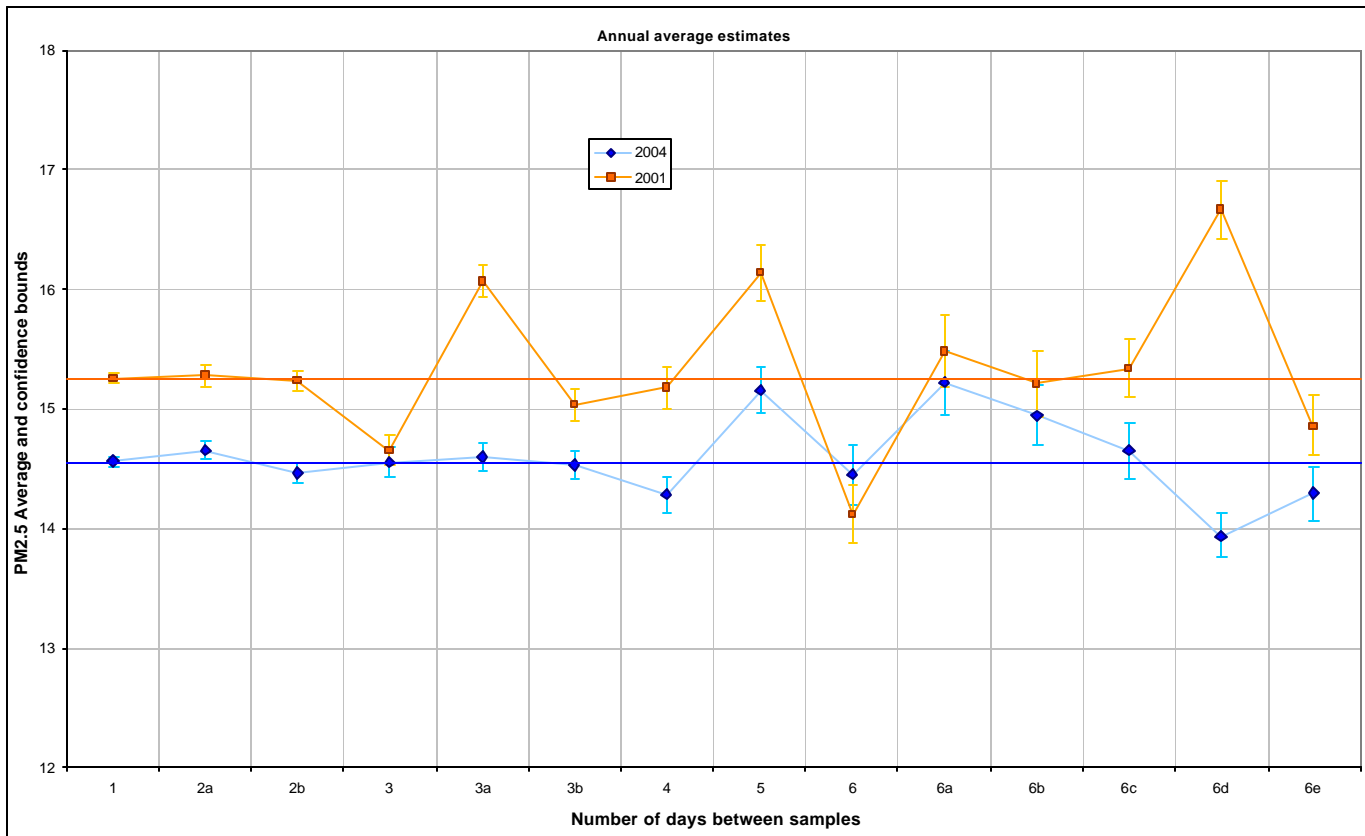
Now that we have lots of data for $PM_{2.5}$, there appears to be a pattern.



‘...reasonably’...’relatively’...’representative’...

Need to test **all** assumptions.

1:3 not guaranteed to be representative



Spatially and Temporally Representative

- The data needs to be representative both over space **and** time.



When evaluating or planning for

‘...reasonably’...’relatively’. ...’representative... **keep in mind:**

Topography matters

Meteorology matters

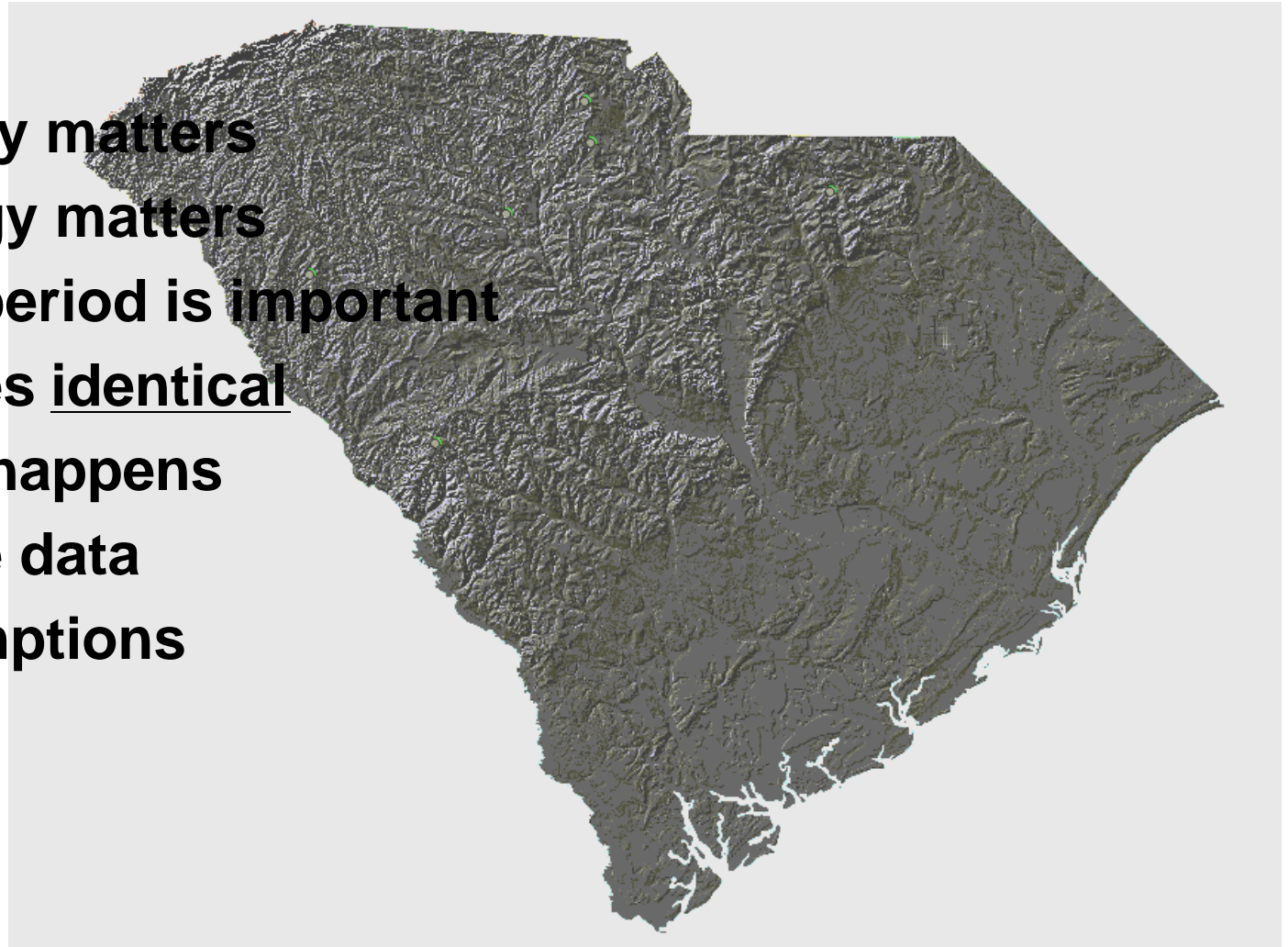
Sampling period is important

No two sites identical

Variability happens

Look at the data

Test assumptions



When evaluating or planning for

'...reasonably'...'relatively'. ...'representative... **keep in mind:**

Topography matters

Meteorology matters

Sampling period is important

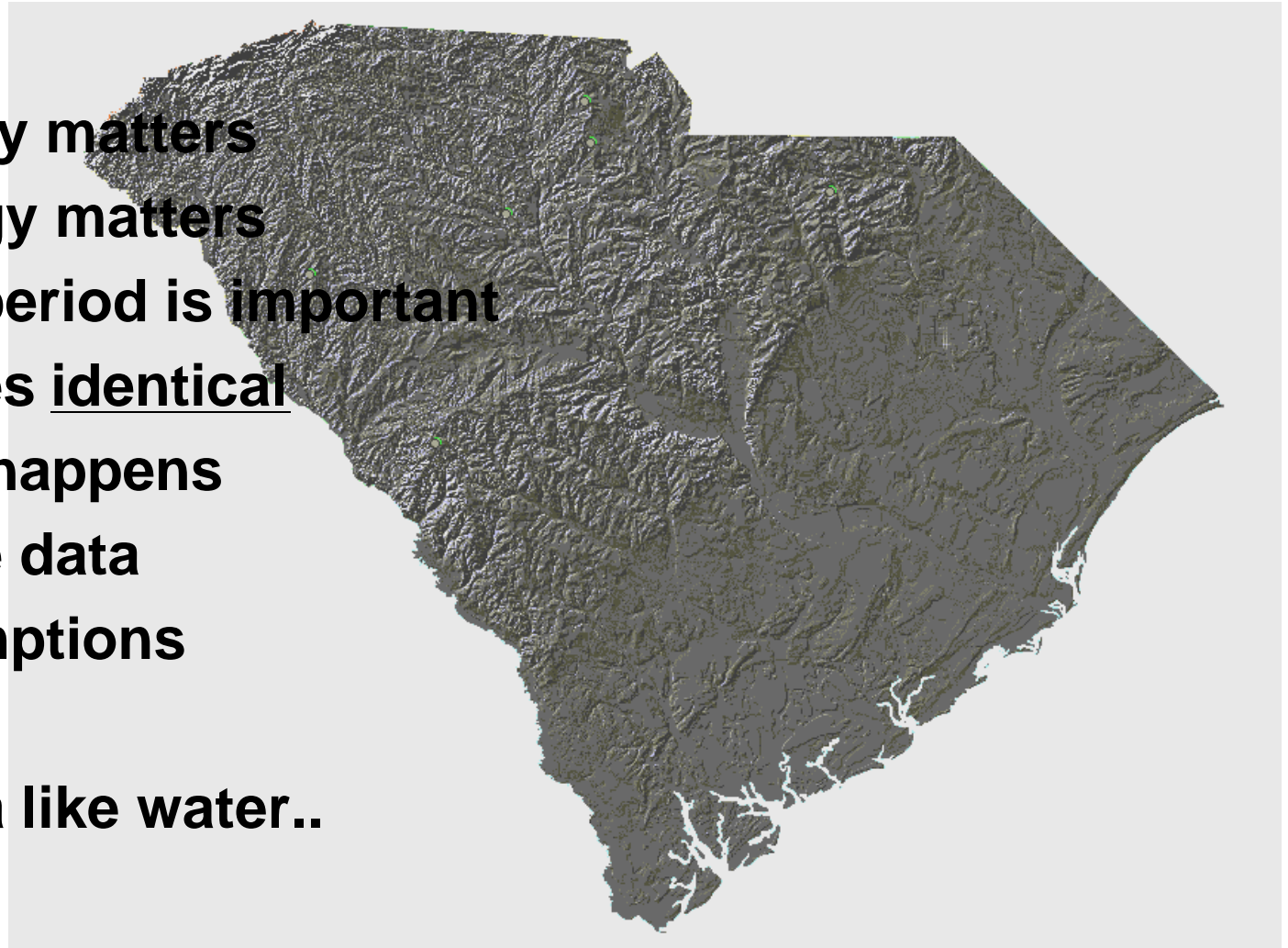
No two sites identical

Variability happens

Look at the data

Test assumptions

Air is kinda like water..

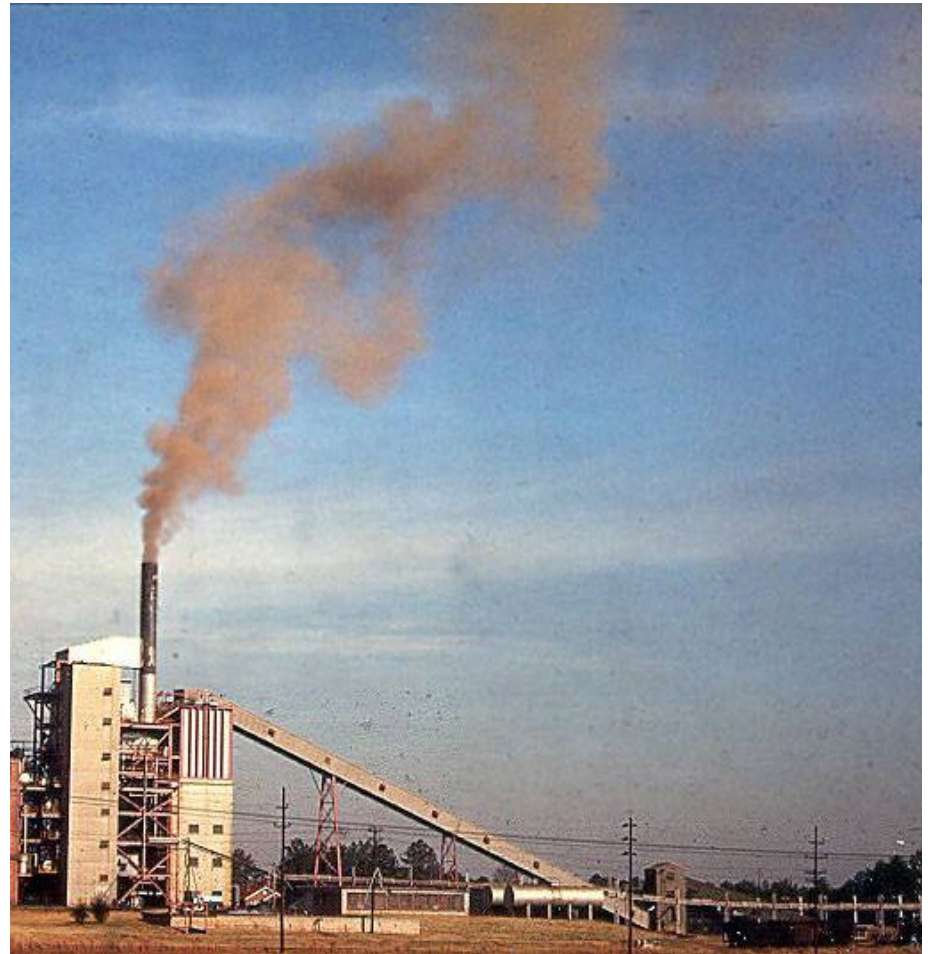


When evaluating or planning for

'...reasonably'...'relatively'. ...'representative... keep in mind:

Like water, there are things that are in solution and things that will settle out...

..and there are things that are inert and things that will change.



individual parameter characteristics

– Gas

- SO_2 NO_2 , CO
- May stay the same for long periods
- May react and change quickly

– Particles

– Primary

– Secondary

individual parameter characteristics

– Gas

– Particles

- TSP, PM₁₀, PM_{2.5}, Lead

- The smaller it is, the more like a gas it behaves..

Figure 1. Comparison of PM sizes.

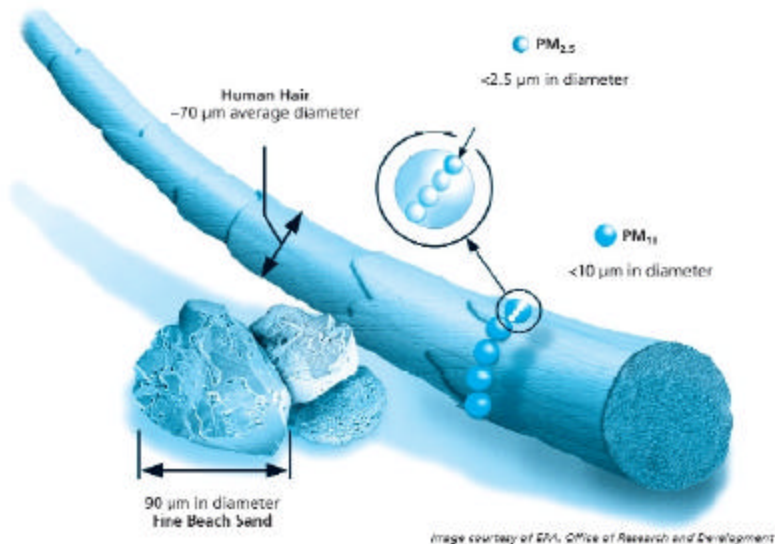


Image courtesy of EPA, Office of Research and Development

s of Network Design 3/15/2006

individual parameter characteristics

- Gas
- **Particles**
 - TSP, PM_{10-2.5}, PM_{2.5}, Lead
 - The smaller it is, the more like a gas it behaves..
- Primary
- Secondary

individual parameter characteristics

- **Gas**
- **Particles**
- **Primary**
 - **Released and doesn't change (until it does)**
 - **CO, EC, soils, or Lead don't change (much)**
- **Secondary**

individual parameter characteristics

- **Gas**
- **Particles**
- **Primary**
- **Secondary**
 - **Changes, or is created in the atmosphere**
 - **Stuff reacts with moisture, light, other chemicals to produce the pollutant of concern.**

Network design criteria Pt 58

SLAMS

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**

More Network design criteria Pt 58

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**
 - **Monitoring Season for Ozone**

Ozone

Middle

Close to NOx sources

Watch the trees

Neighborhood

Urban subregion

Testing concepts and models

May be high when stagnant

More Network design criteria Pt 58

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**

Carbon Monoxide

Micro

Street canyons

Hot spot

Middle

**Geometry of the rep.
area (roads)**

Possibly parking lots..

More Network design criteria Pt 58

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**
 - **Number of sites**
 - **By population**
 - **By objective**

PM_{2.5}

Micro

Street canyons

Hot spot

Neighborhood

**Most pop exposure
associated with this
scale**

Assumed unless....

More Network design criteria Pt 58

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**
 - **Number of sites**
 - **By population**
 - **By objective**
 - **Encouraged spatial averaging**

PM_{2.5}

Core

2 per MSA > 500,000

1 per MSA > 200,000

‘...more than minimum should be deployed..’

Also:

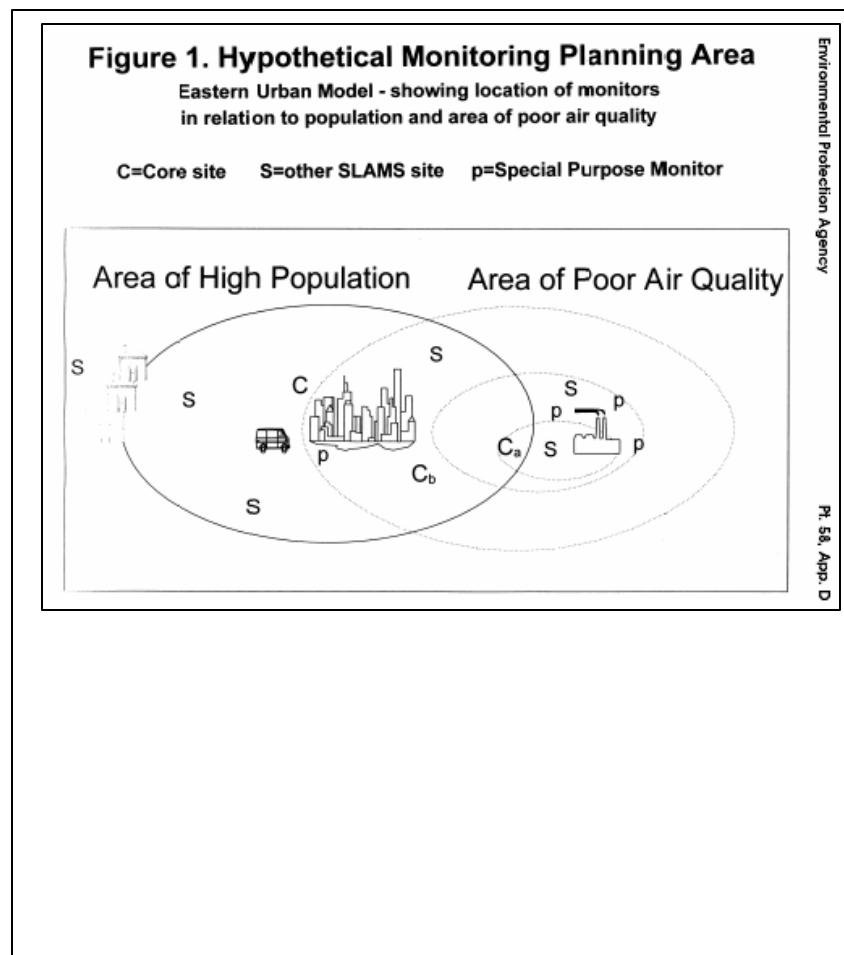
Regional Background

Transport

1 per each 200,000 outside MSAs

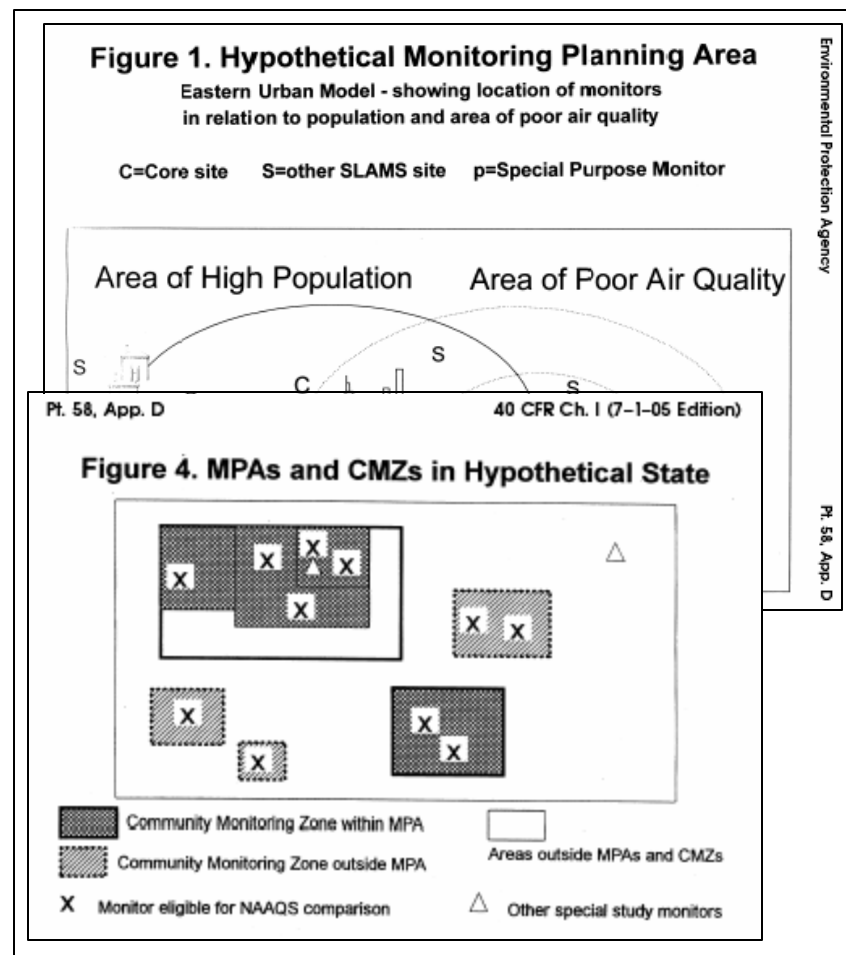
More Network design criteria Pt 58

- **By Parameter**
 - **Appropriate scales**
 - **Types of locations**
 - **Objective**
 - **Number of sites**
 - **By population**
 - **By objective**
 - **Encouraged spatial averaging**



More Network design criteria Pt 58

- **By Parameter**
 - Appropriate scales
 - Types of locations
 - Objective
 - Number of sites
 - By population
 - By objective
 - Encouraged spatial averaging



More Network design criteria Pt 58

NAMS

- **By Parameter**
 - **Specify minimum numbers**
 - **By population and concentration**

Pt. 58, App. D

TABLE 3—SO₂ NATIONAL AIR MONITORING
STATION CRITERIA

[Approximate number of stations per area]^a

Population category	High concentration ^b	Medium concentration ^c	Low concentration ^d
>1,000,000	6–10	4–8	2–4
500,000 to 1,000,000	4–8	2–4	1–2
250,000 to 500,000	3–4	1–2	0–1
100,000 to 250,000	1–2	0–1	0

^a Selection of urban areas and actual number of stations per area will be jointly determined by EPA and the State agency.

^b High concentration—exceeding level of the primary NAAQS.

^c Medium concentration—exceeding 60 percent of the level of the primary or 100% of the secondary NAAQS.

^d Low concentration—less than 60 percent of the level of the primary or 100% of the secondary NAAQS.

More Network design criteria Pt 58

Helpful summary tables...

TABLE 6—SUMMARY OF SPATIAL SCALES FOR SLAMS AND REQUIRED SCALES FOR NAMS

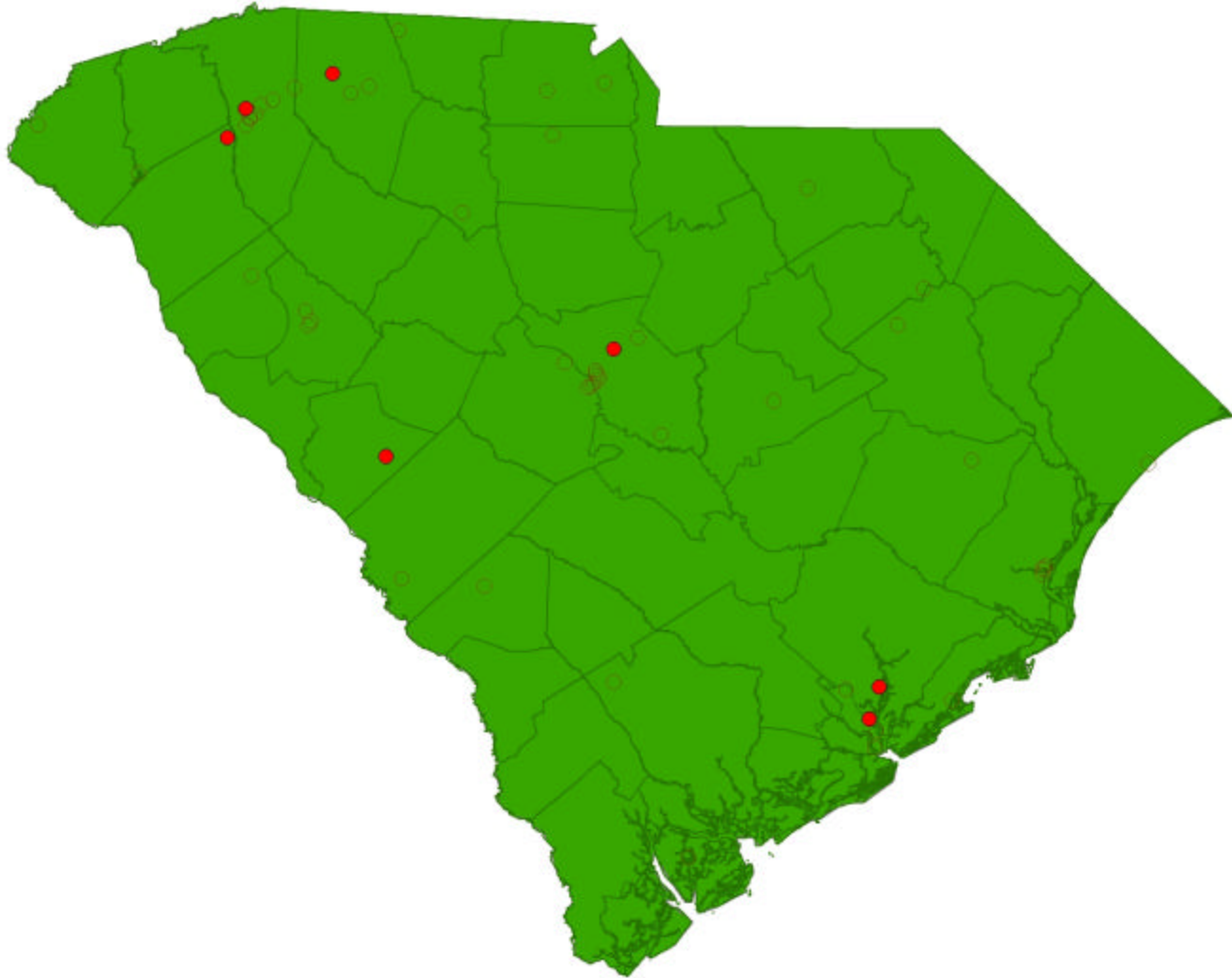
Spatial Scale	Scales Applicable for SLAMS						
	SO ₂	CO	O ₃	NO ₂	Pb	PM ₁₀	PM _{2.5}
Micro		✓			✓	✓	✓
Middle	✓	✓	✓	✓	✓	✓	✓
Neighborhood	✓	✓	✓	✓	✓	✓	✓
Urban	✓		✓	✓	✓	✓	✓
Regional	✓		✓		✓	✓	✓
Scales Required for NAMS							
Micro		✓			✓	✓	✓ ¹
Middle					✓	✓	✓ ¹
Neighborhood	✓	✓	✓	✓	✓	✓	✓
Urban			✓	✓			✓ ²
Regional							✓ ²

¹ Only permitted if representative of many such micro-scale environments in a residential district (for middle scale, at least two).

² Either urban or regional scale for regional transport sites.

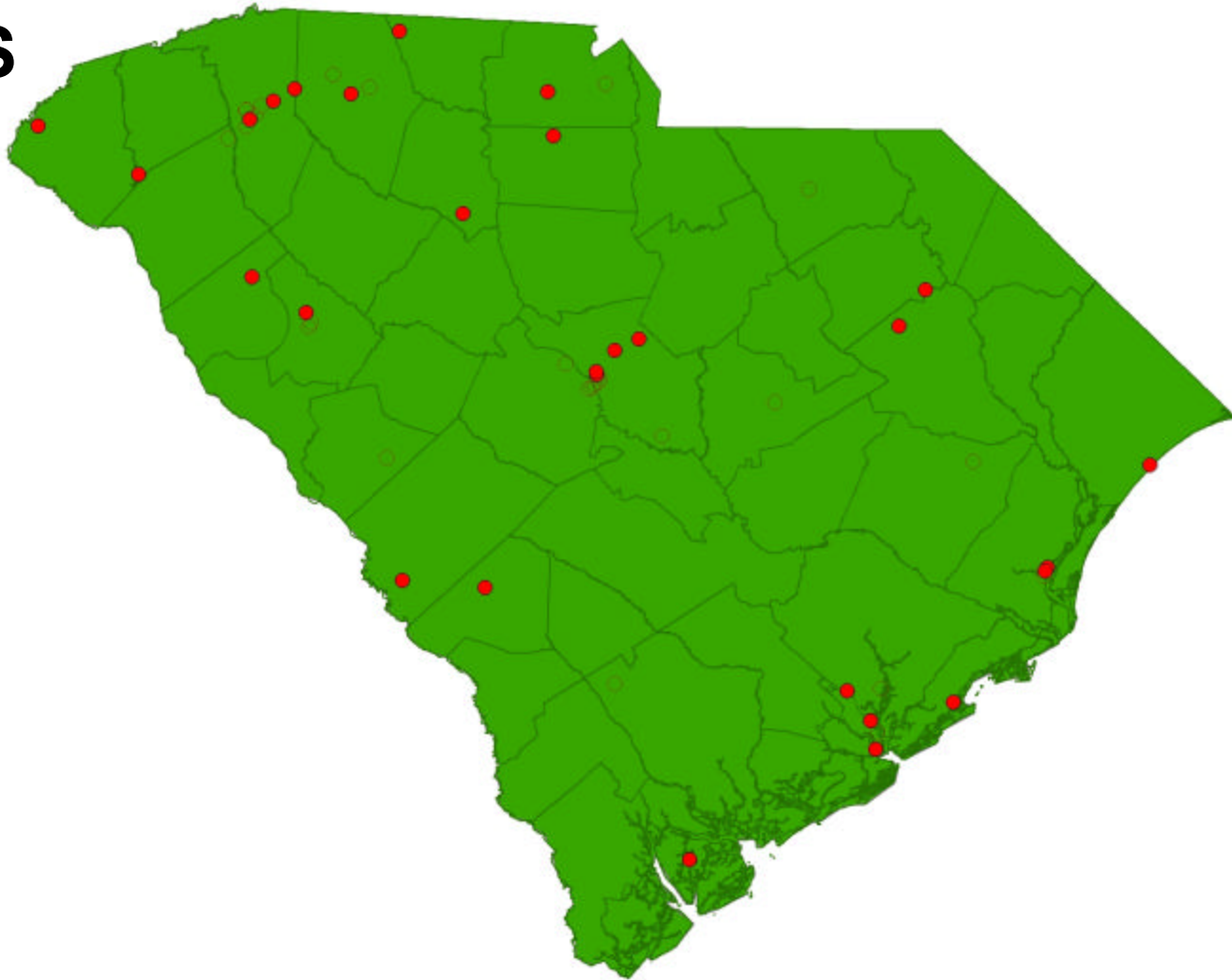
SC Network

NAMS



SC Network

SLAMS



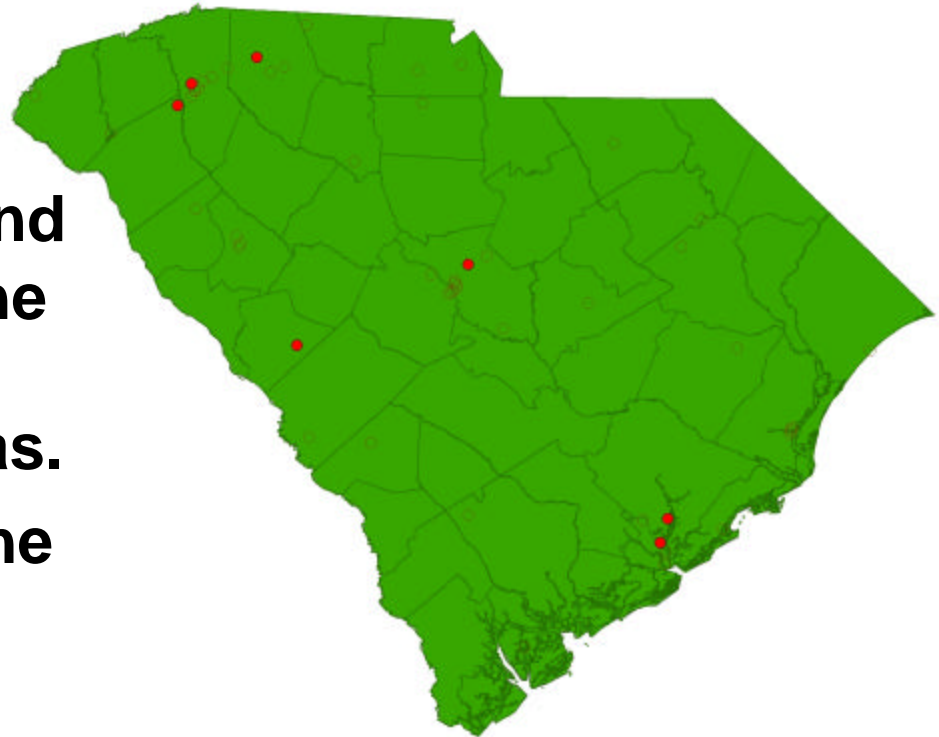
Network design criteria Pt 58

Our Helpful summary tables...

	SO ₂	CO	Ozone	NO ₂	Lead	PM ₁₀	PM _{2.5}
NAMS	1	-	5	-	-	2	(5)*
SLAMS	3	1	12	3	4	12	10
SPMs	8	3	4	4	17	4	12

Network design criteria Pt 58

- **NAMS intended to**
 - ..provide data for national policy analysis/trends and for reporting to the public on major metropolitan areas.
 - **Comparison to the standards**

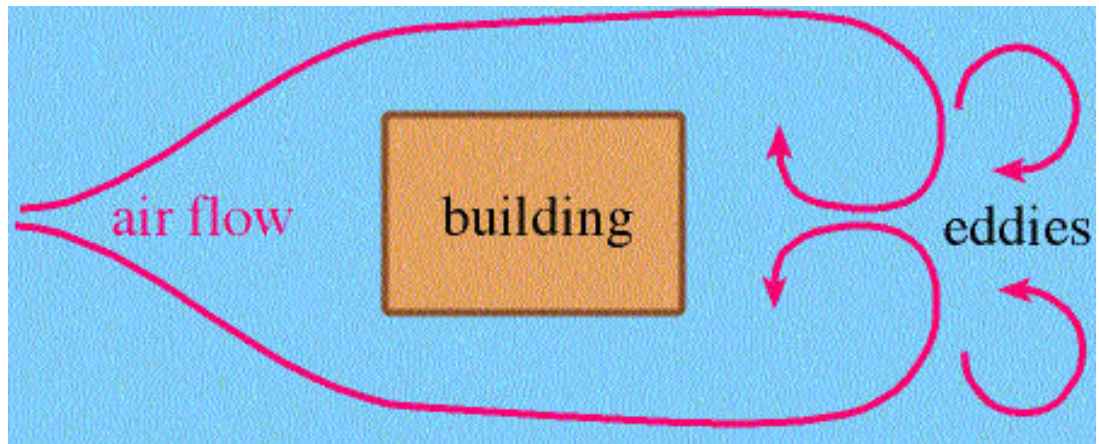


Site requirements

- **To increase the probability that the specific site will be reasonably representative**
 - **General**
 - **Free air flow**
 - prevailing winds, obstructions
 - **No local sources that unduly impact**
 - **Probe location- height, distance from sources**

Site requirements

- **Free air flow- consider impact of ...**
 - Buildings
 - Walls
 - Trees



Consider predominant wind direction and sources (in the context of the objective)

Site requirements

- **Probe location - ideally in the breathing zone, but consider:**
 - **Characteristics of the pollutant**
 - **Scale**
 - **Objective**
 - **Operation of the site**

Site requirements

- **Probe location - distance from roadways.**
 - Chart or graph for every criteria pollutant except SO₂
 - Based on average daily traffic

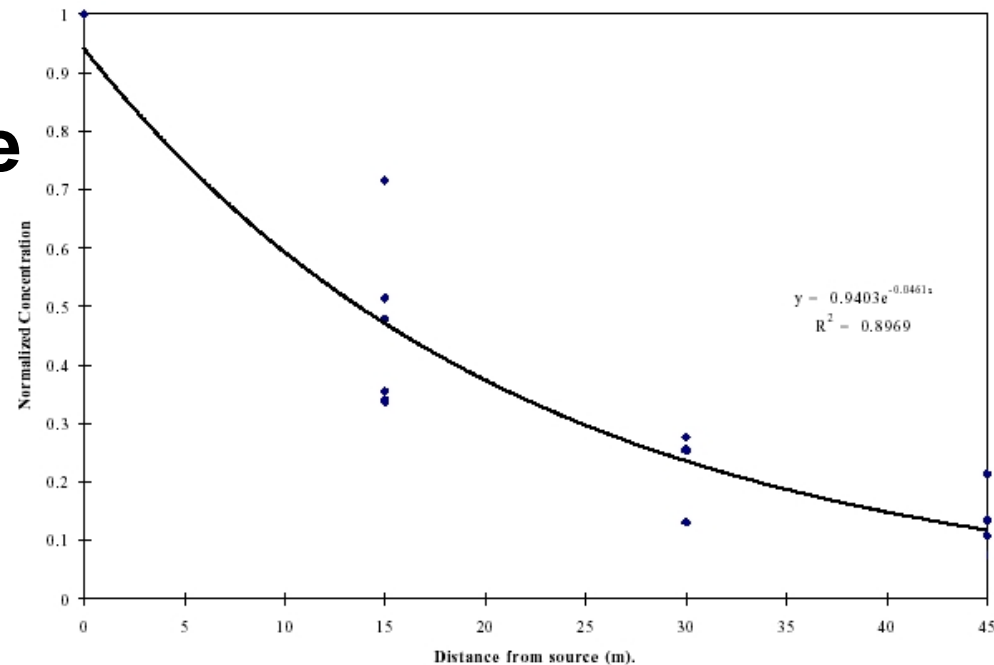


Figure 2.1.7. Normalized PM₁₀ concentrations at increasing distances from an unpaved road (Watson *et al.*, 1996). Samples were taken at 2 m above ground level.

Site requirements

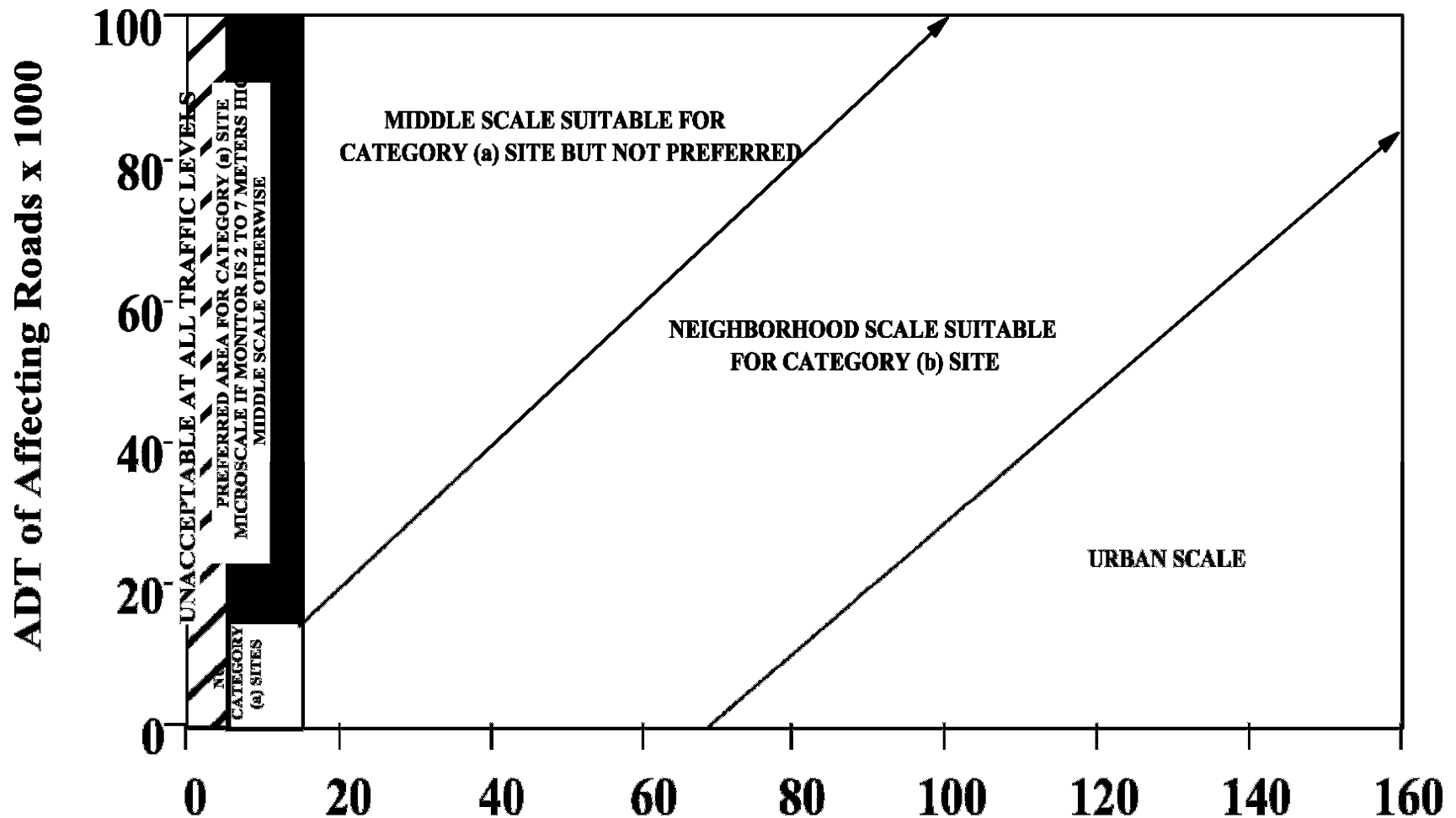
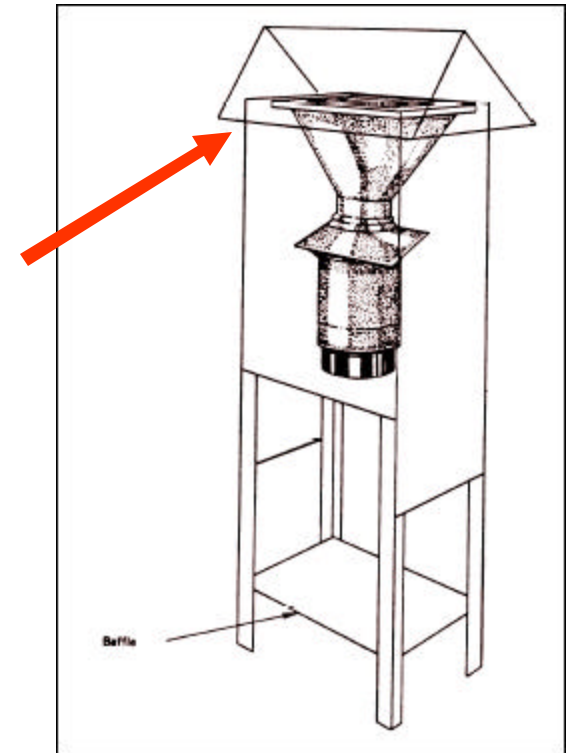


Figure E-1. Distance of PM samplers to nearest traffic lane (meters)

Probe?



Probe?



TABLE 5—SUMMARY OF PROBE AND MONITORING PATH SITING CRITERIA

Pollutant	Scale [maximum monitoring path length, meters]	Height from ground to probe or 90% of monitoring path ^A (meters)	Horizontal and vertical distance from supporting structures ^B to probe or 90% of monitoring path ^A (meters)	Distance from trees to probe or 90% of monitoring path ^A (meters)	Distance from roadways to probe or monitoring path ^A (meters)
SO ₂ ^{C,D,E,F}	Middle [300m] Neighborhood, Urban, and Regional [1km].	3–15	>1	>10	N/A.
CO ^{D,E,G}	Micro Middle [300m] Neighborhood [1km].	3±0.5; 3–15	>1	>10	2–10; See table 2 for middle and neighborhood scales.
O ₃ ^{C,D,E}	Middle [300m] Neighborhood, Urban, and Regional [1km].	3–15	>1	>10	See table 1 for all scales.
Ozone precursors (for PAMS) ^{C,D,E}	Neighborhood and Urban. [1 km]	3–15	>1	>10	See table 4 for all scales.
NO ₂ ^{C,D,E}	Middle [300m] Neighborhood and Urban [1km].	3–15	>1	>10	See table 1 for all scales.
Pb ^{C,D,E,F,H}	Micro; Middle, Neighborhood, Urban and Regional.	2–7 (Micro); 2–15 (All other scales).	>2 (All scales, horizontal distance only).	>10 (All scales)	5–15 (Micro); See table 3 for all other scales.
PM–10 ^{C,D,E,F,H}	Micro; Middle, Neighborhood, Urban and Regional.	2–7 (Micro); 2–15 (All other scales).	>2 (All scales, horizontal distance only).	>10 (All scales)	2–10 (Micro); See Figure 2 for all other scales.

N/A—Not applicable.

^AMonitoring path for open path analyzers is applicable only to middle or neighborhood scale CO monitoring and all applicable scales for monitoring SO₂, O₃, O₃ precursors, and NO₂.

^BWhen probe is located on a rooftop, this separation distance is in reference to walls, parapets, or penthouses located on roof.

^CShould be >20 meters from the dripline of tree(s) and must be 10 meters from the dripline when the tree(s) act as an obstruction.

^DDistance from sampler, probe, or 90% of monitoring path to obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler, probe, or monitoring path. Sites not meeting this criterion may be classified as middle scale (see text).

^EMust have unrestricted airflow 270° around the probe or sampler; 180° if the probe is on the side of a building.

^FThe probe, sampler, or monitoring path should be away from minor sources, such as furnace or incineration flues. The separation distance is dependent on the height of the minor source's emission point (such as a flue), the type of fuel or waste burned, and the quality of the fuel (sulfur, ash, or lead content). This criterion is designed to avoid undue influences from minor sources.

^GFor microscale CO monitoring sites, the probe must be >10 meters from a street intersection and preferably at a midblock location.

^HFor collocated Pb and PM–10 samplers, a 2–4 meter separation distance between collocated samplers must be met.

Probe Siting Criteria

Site requirements

- **To increase the probability that the specific site will be reasonably representative**
 - **General**
 - **Specific**
 - A pollutant may have specific needs to ensure collection of consistent, unbiased data.
 - Probe material
 - interferences

Site requirements

Guidance documents for PM, SO₂, Ozone, Lead (and some noncriteria) available.

Links on DHEC web site, Ambient Air Network page

Ozone - Guideline on Ozone Monitoring Site Selection EPA-454/R-98-002 August 1998

PM - Guidance for Network Design and Optimum Site Exposure for PM_{2.5} and PM₁₀
EPA-454/R-99-022 December 1997

SO₂ - Optimum Site Exposure Criteria for SO₂ Monitoring EPA-450/3-77-013 April 1977

Lead -Guidance for Siting Ambient Air Monitors Around Stationary Lead Sources EPA-454/R-92-009R, August 1997

PSD - Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)
EPA-450/4-87-007 May1987

Noncriteria - Network Design and Site Exposure Criteria for Selected Noncriteria Air Pollutants EPA-450/4-84-022 September 1984

Ozone Precursors - Site Selection for the Monitoring of Photochemical Air Pollutants, April 1978

Visibility - Visibility Monitoring Guidance EPA-454/R-99-003 June 1999

Guidance

– **Quality Assurance**

- **Redbook (Quality Assurance Handbook for Air Pollution Measurement Systems EPA 600/9-76-005)**

Network Design

Strike a balance between:

- **Omniscient**
 - everywhere, all the time
- **The minimum**
- **Be Practical...**
 - make (and test) assumptions
 - use representative sites
 - bias towards worst case
 - maximize resources

Sampling/Monitoring strategies

- **Random**
- **Judgmental**
- **Stratified**
- **Systemic (Grid)**
- **Ranked**
 - Professional judgment
- **Adaptive Cluster**
 - Adjust as you learn

Because we have some information in the beginning ..

- Pollutant sources
- Characteristics
- Data
- Models

...we can use the best blend of techniques to plan

Sampling/Monitoring strategies

- **Random**
- **Judgmental**
- **Stratified**
- **Systemic (Grid)**
- **Ranked**
 - Professional judgment
- **Adaptive Cluster**
 - Adjust as you learn
- **Required**

Because we have some information in the beginning ..

- Pollutant sources
- Characteristics
- Data
- Models

...we can use the best blend of techniques to plan.

PROCESS

Process

- **Network Design**
 - Starting from scratch..
 - New pollutant or special study
- **Review / Assessment**
 - Existing Network
 - Meeting requirements?
 - Meeting needs?

Process

- **Process similar**
 - **Assemble team**
 - **Check requirements**
 - **Analyze the data**
 - **Determine needs**
 - **Make recommendations**
 - **Prioritize**
 - **Draft the plan**
 - **Address comments**
 - **Implement**

Process

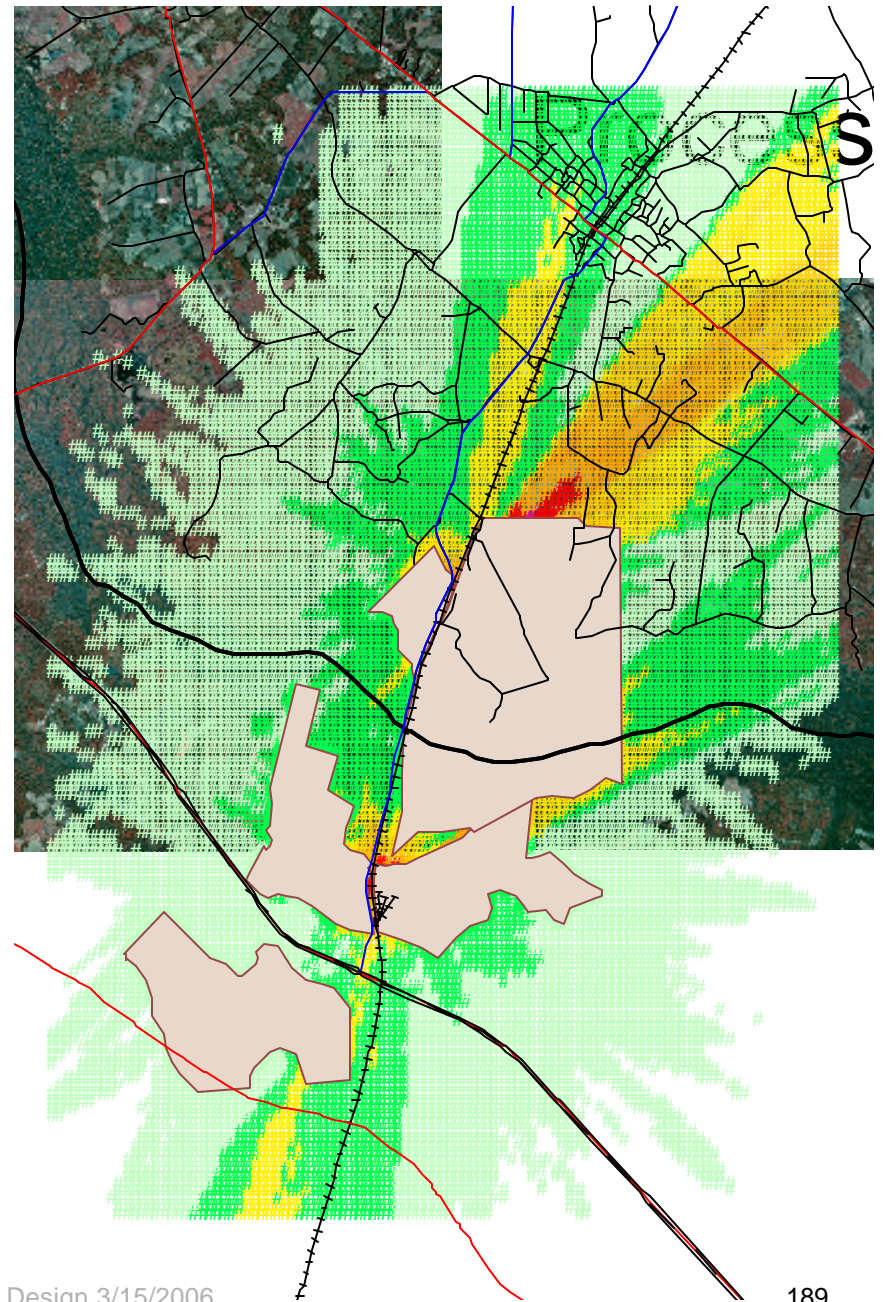
- **Process similar**
 - Assemble team
 - Check requirements
 - Analyze the data
 - Determine needs
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 - Draft Monitoring Plan
 - Address comments
 - Implement

The biggest difference in design and assessment is that more data is available for assessment.

Process

- **Assemble the team**
 - **Monitoring**
 - **Meteorology**
 - **Modeling**
 - **Data**
 - **Permitting**
 - **Planning**
 - **Community Liaison**

- **Assemble the team**
 - **Monitoring**
 - **Meteorology**
 - **Modeling**
 - **Data**
 - **Permitting**
 - **Planning**
 - **Community Liaison**



Process

- **Check against the Rule...**
 - Requirements met?
 - Intent met?
 - Deficiencies Addressed?

Process

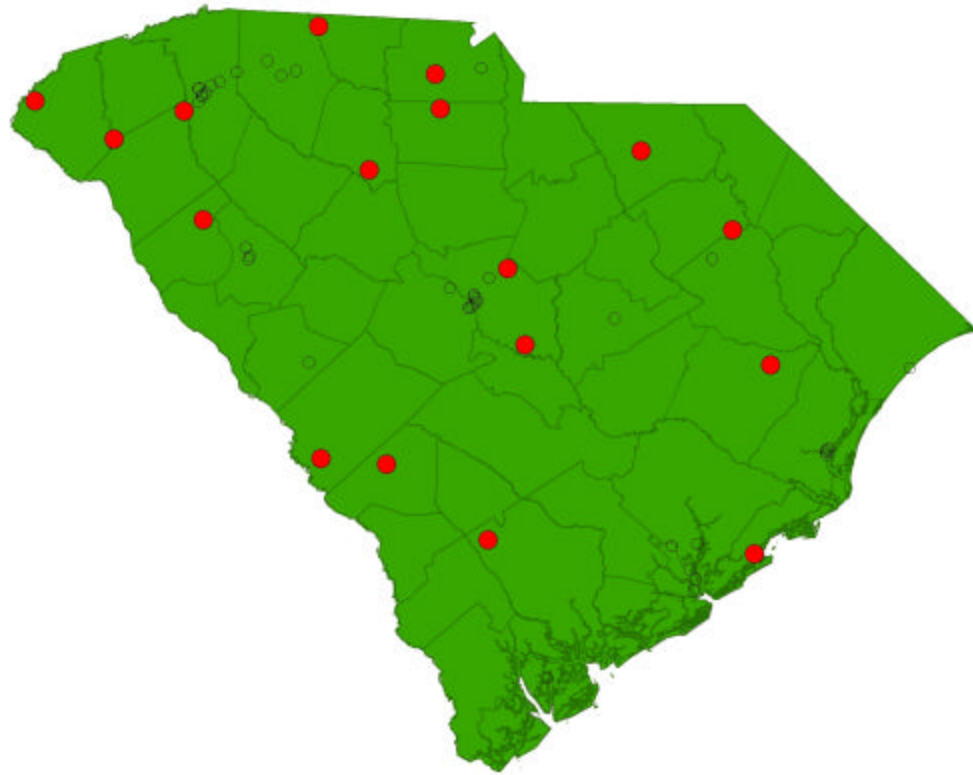
- **Check against the Rule...**
- **Analyze the data**
 - **Catch the easy stuff**
 - **Analysis may raise more questions**

Middle Scale ?

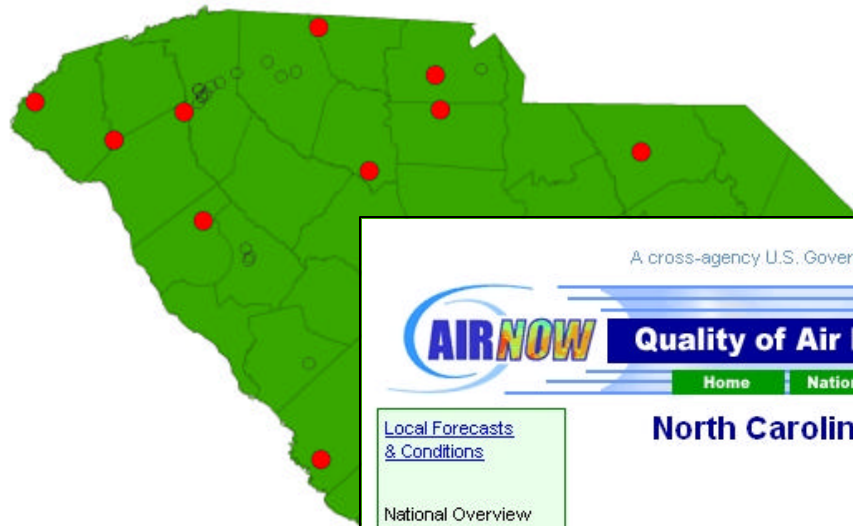


Middle Scale ?






Middle Scale ?




Middle Scale ?

A cross-agency U.S. Government Web site. See a complete [list of AIRNow partner agencies](#) Search: **GO**

































Quality of Air Means Quality of Life

Home | National Forecast | Local Forecasts & Conditions | Partners



North Carolina / South Carolina Ozone Maps for June, 2003

June 2003 ▶

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 	2 	3 	4 	5 	6 	7 
8 	9 	10 	11 	12 	13 	14 
15 	16 	17 	18 	19 	20 	21 
22 	23 	24 	25 	26 	27 	28 
29 	30 					

Southeast Air Quality Conditions - Maps Archives

[Local Forecasts & Conditions](#)

National Overview

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[Archives](#)

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[AQI Summary](#)

[About AIRNow](#)

Air Quality Basics

[Air Quality Index](#)

[Ozone](#)

[Particle Pollution](#)

[UV](#)

The AQI for...

[Health Providers](#)

[Kids](#)

[Older Adults](#)

[Partner agencies](#)

[Teachers](#)

[Weathercasters](#)

Key Topics:

[Your Health](#)

[Smoke from Fires](#)

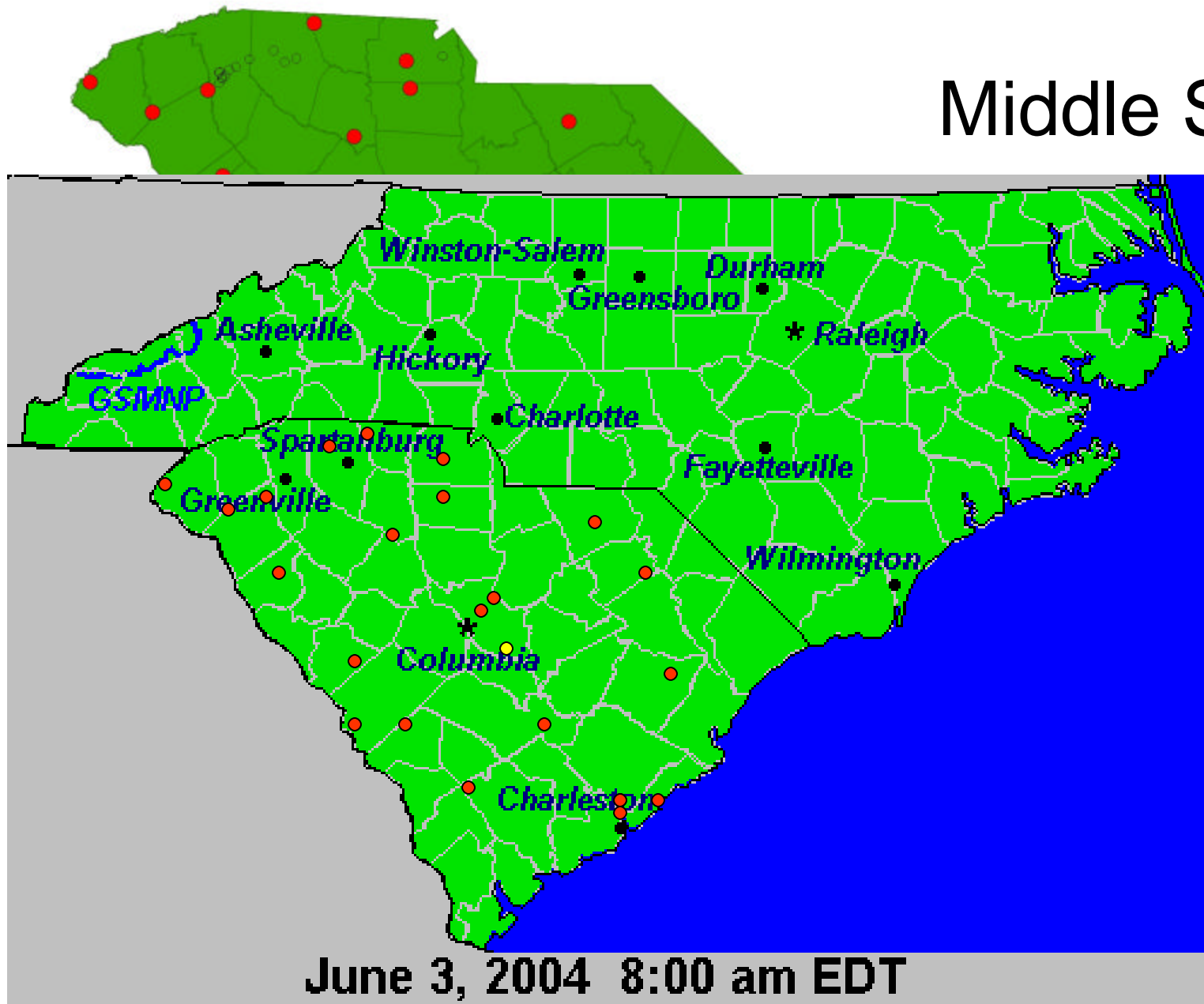
Resources

[Publications](#)

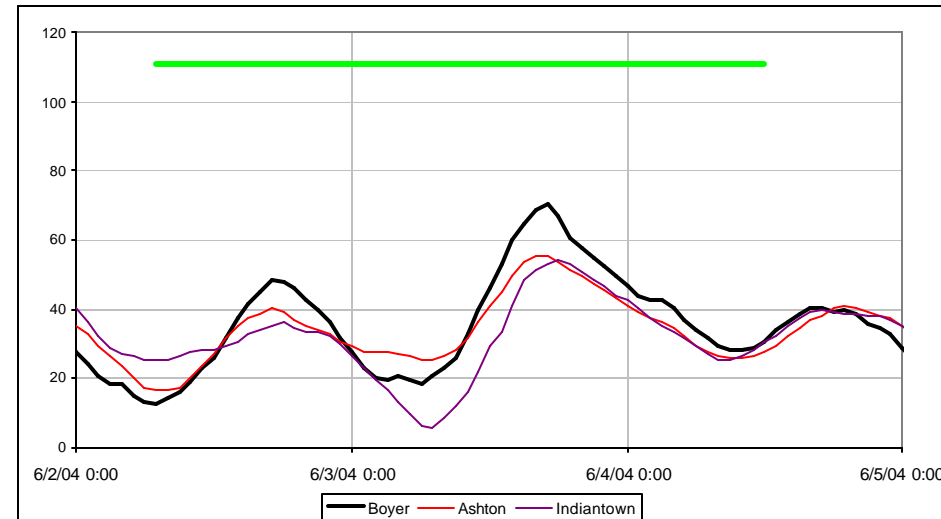
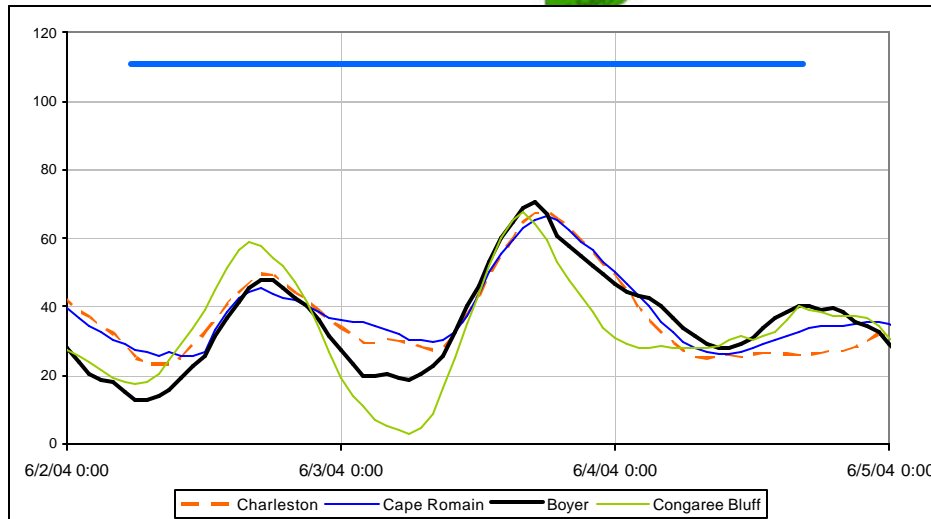
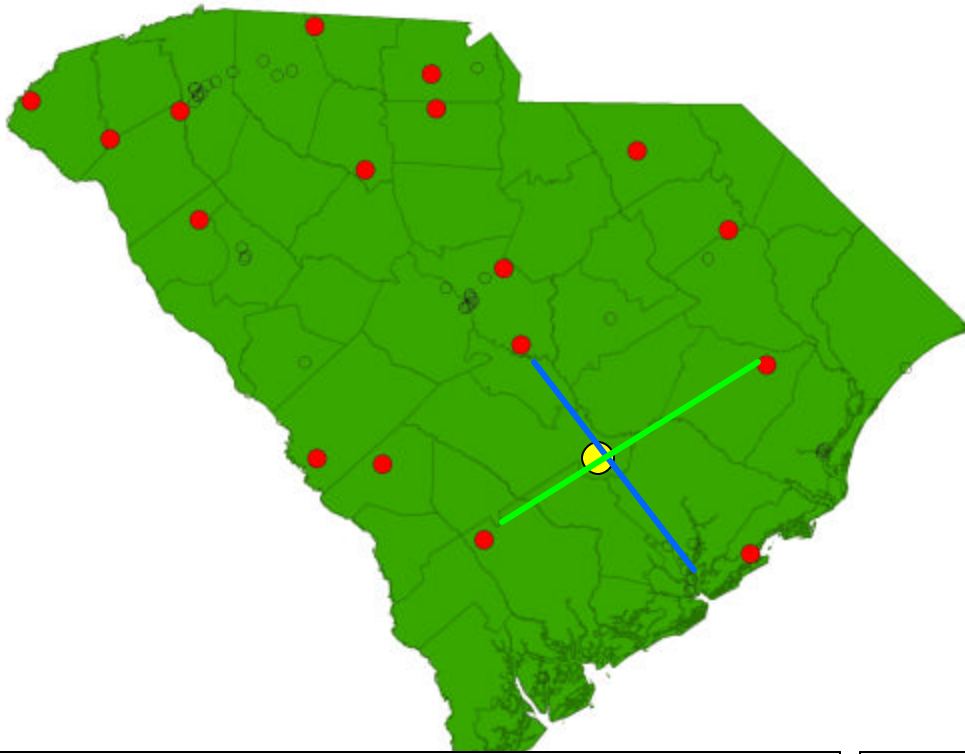
[Publicaciones](#)

[FAQ](#)

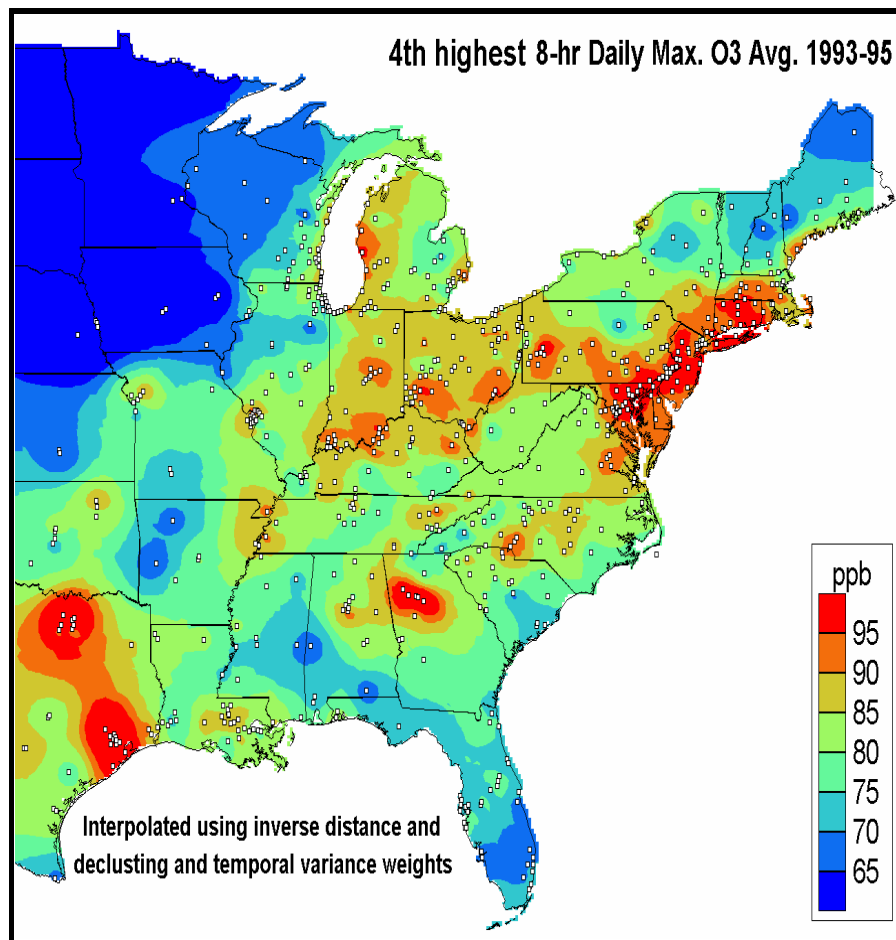
Middle Scale ?



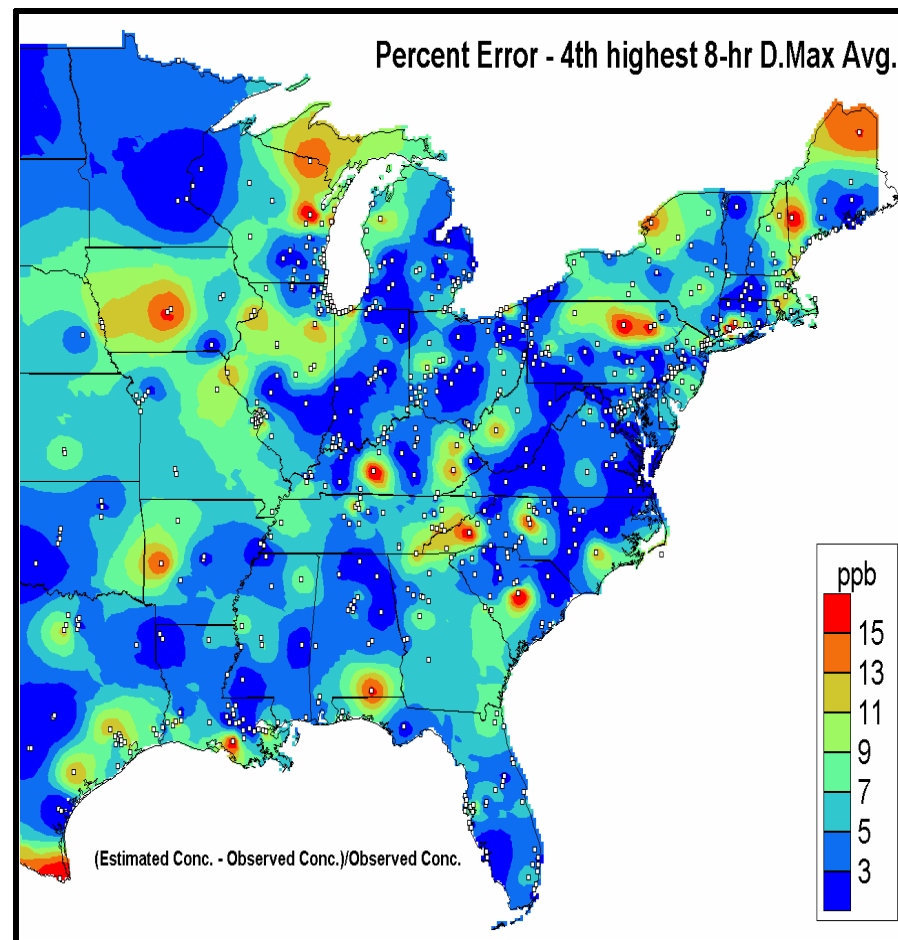
Urban Scale!



Base case ozone surface all sites



Error surface after site removal



Process

- Check against the Rule...
- **Analyze the data**
 - Gather resources
 - Catch the easy stuff
 - Analysis may raise more questions

– Resources

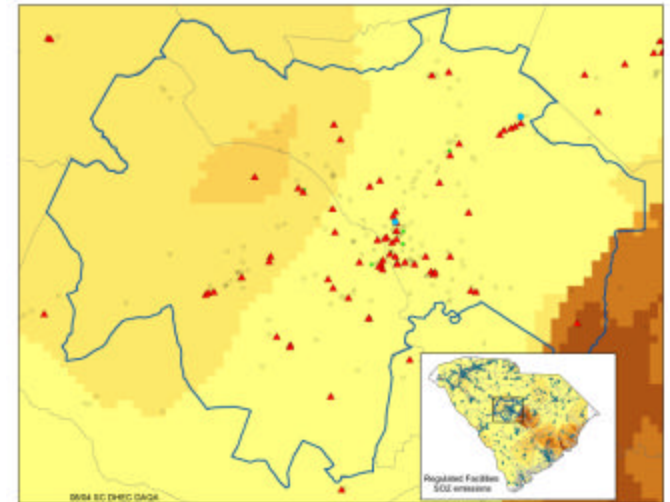
Review

- Requirements
- Objectives (network and site specific)
- Network description
- Site descriptions
- Air quality summaries
- Access to data
- Emissions inventory and trends
- Area Climatology/Typical Site Meteorology
- Population trends
- Projections
- Enforcement actions
- Maps

- » *Network*
- » *Sources*
- » *Population*
- » *Topography*

- Previous Reviews

- » *Region 4 Assessment of Ambient Air Monitoring Networks (Final 2005)*



Process

- Check against the Rule...
- Analyze the data
- **Assemble the questions**
 - Synchronize and prioritize

Process

- **What are the Questions to be answered? - Questions drive the design.**

Process

**What are the Questions to be answered? -
Questions drive the design.**

- **Compliance**
 - Highest concentration
 - population density- in particular when in vicinity of high concentration
 - air quality entering the area
 - areas of projected growth
 - evaluation of control strategies
 - represent all areas

**What are the Questions to be answered? -
Questions drive the design.**

- **Emergency**
 - in densely populated areas
 - near large sources
 - near sensitive populations (hospitals, schools, etc.)
 - near high traffic density

Process

**What are the Questions to be answered? -
Questions drive the design.**

- **Trends - a few sites representing large spatial scales**
 - background
 - context
 - minimal local source impact

Process

**What are the Questions to be answered? -
Questions drive the design.**

- **Research**
 - **Health effects**
 - **Fate of pollutants**
 - **Development of tools**
 - **Models**
 - **Source apportionment**

**What are the Questions to be answered? -
Questions drive the design.**

- **Health effects**
 - in or near population being studied
 - averaging times appropriate for acute or chronic exposure and effect
 - typically higher frequency (daily or less)

Process

**What are the Questions to be answered? -
Questions drive the design.**

- **Pollutant studies**
 - **formation and reaction**
 - **precursors / intermediates**
 - **sources**

Process

**What are the Questions to be answered? -
Questions drive the design.**

- **Planning**
 - **Source apportionment**
 - **Effectiveness of control measures**

Process

- **Questions (no order)**

- Required number of monitors and reflecting the regulations' intent for NAAQS?
- Required monitors for all special monitoring networks (speciation, visibility, toxics)?
- Operating according to documented requirements?
- How long since last review?
- Designation status and timing?
- Do results of special studies indicate need for change?
- Are there proposed or impending network modifications?
- Are there current or expected changes in population, emissions, land use?
- Do NAAQS changes require review and realignment of monitoring?
- Are some populations /areas poorly represented?
- Is there redundancy in the network?
- ?

Process

- **Develop and understand the monitoring objective(s) and appropriate Data Quality Objectives**

Process

- **Identifying the spatial and temporal scale most appropriate for the site monitoring objective**
 - **Spatial**
 - **Max concentration - Micro, Middle, Neighborhood, Urban (rarely)**
 - **Max exposure to population- Neighborhood, Urban**
 - **Impacts of sources - Micro, Middle, Neighborhood**
 - **Transport- Urban, Regional**
 - **General/Background- Neighborhood, Regional**
 - **Welfare -Urban, Regional**

- **Identifying the spatial and temporal scale most appropriate for the site monitoring objective**
 - **Temporal**
 - **Continuous - = 1 hr - local source/acute effects**
 - **Integrated**
 - *temporal - = 1hr - = 24 hour samples*
 - *spatial - open path*
 - **Static- exposure samplers- special studies**

Process

- **Identify the general locations where the monitoring site should be placed**
 - **Impacts of known emissions and sources at site**
 - **Representativeness of site (appropriate to intended scale)**
 - **Pollutant specific concerns**
 - **Topography**

Process

- **Identify specific monitoring sites**
 - **Availability (public property?)**
 - **Cost**
 - **Safety/Security**
 - **Logistics**
 - **Access**
 - **Utilities (Power, Communication)**
 - **Duration of availability**
 - **Meteorology**
 - **Topography**

Process

- **Process**
 - **Assemble team**
 - **Check requirements**
 - **Determine needs**
 - **Analyze the data**
 - **Make recommendations**
 - **Prioritize**
 - **Draft Monitoring Plan**
 - **Address comments**
 - **Implement**

Process

- **Process**

- Assemble team
- Check requirements
- Determine needs
- Analyze the data
- Make recommendations
- Prioritize
- Draft Monitoring Plan
- Address comments
- Implement

- ..And in parallel

- Identify Stakeholders
- Provide Training
- Provide access to resources
- Gather input
- Identify opportunities

Process

- **Stakeholders identified**
 - **Air Program**
 - **Environment**
 - **Resource Managers**
 - **Health**
 - **Communities**
 - **Business**
 - **Research**

Process

- **Provide Training (this meeting)**

Process

- **Provide Training (this meeting)**
- **Provide resources**
 - **Web Page**
 - **Request**

Process

- Provide Training (this meeting)
- Provide resources
- **Gather input**
 - Air Program planning needs
 - Stakeholder questions

Process

- Provide Training (this meeting)
- Provide resources
- Gather input
- **Define required networks**

Process

- Provide Training (this meeting)
- Provide resources
- Gather input
- Define required networks
- **Identify needs beyond the required**
 - identify
 - prioritize

Process

- Provide Training (this meeting)
- Provide resources
- Gather input
- Define required networks
- Identify needs beyond the required
- **Draft Monitoring Plan**
 - **Comment**
 - **Revise**

Process

- Provide Training (this meeting)
- Provide resources
- Gather input
- Define required networks
- Identify needs beyond the required
- **Draft Monitoring Plan**

**Complete network assessment due by
July 1, 2007**

Process

- Provide Training (this meeting)
- Provide resources
- Gather input
- Define required networks
- Identify needs beyond the required
- Draft Monitoring Plan
- **Implement**

Process

- **Repeat**

Process

- **Regular complete network review**
 - **By parameter**
 - minimums met
 - objectives addressed
 - revisions addressed in Monitoring Plan
 - **By area**
 - MSA?
 - minimums met
 - needs met

Practical

Practical considerations

Practical considerations

The perfect site is not available...

Reality check

- **Where you plan vs. where you can..**
 - **Access**
 - **Permission**
 - **Exposure**
 - **Time**
 - **Cost**

Reality check

- **Where you plan vs. where you can..**
 - **Access**
 - **Permission**
 - **Exposure**
 - **Time**
 - **Cost**

If an existing site
can reasonably be
used to meet the
objective,
you will probably
use it.

Reality check

- **Where you plan vs. where you can..**
 - **Access**
 - **Permission**
 - **Exposure**
 - **Time**
 - **Cost**

If an existing site
still serves the
objective,
try to
preserve it.

Reality check

- **Can you pay your way..?**
Every data point collected has a cost.
 - **Equipment**
 - **Infrastructure**
 - **Personnel**
 - **Operation**
 - **Utilities**
 - **QA**
 - **Data Management**
 - **Reporting**

Reality check

- **Can you pay your way..?**

Every data point collected has a cost.

- **Equipment**
- **Infrastructure**
- **Personnel**
- **Operation**
- **Utilities**
- **QA**
- **Data Management**
- **Reporting**

Some times the
incremental cost
for useful data is
small.

Do it.

Reality check

- **Can you pay your way..?**

Every data point collected has a cost.

- **Equipment**
- **Infrastructure**
- **Personnel**
- **Operation**
- **Utilities**
- **QA**
- **Data Management**
- **Reporting**



Individual sites -

- **Can you pay your way..?**

Every data point collected has a cost.

- Equipment
- Infrastructure
- Personnel
- Operation
- Utilities
- QA
- Reporting
- Data Management



Good Science

To answer the question you need:

- The right data**
 - **Quality Assurance Project Plan (QAPP)**
- Data of known quality**
 - **Precise**
 - **Accurate**
- Unbiased data**
 - **Quality Assurance (QA)**

EQC Quality Management Plan (QMP)

Finally.....

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Collecting data representative of exposure of the general population**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Collecting data representative of exposure of the general population Representative**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Collecting data representative of exposure of sensitive populations**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Collecting data representative of exposure of sensitive populations Worst Case**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Providing context**
 - **Adequate representation of the state**
 - *Population centers*
 - *Small cities and rural areas*
 - *Pristine areas*
 - **Measurement continuity**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Providing data of known quality**
 - **Measurement consistency**
 - **Measurement transparency**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Providing data that supports understanding**

Philosophy

- **Be sure we support the DHEC mission:** *'We promote and protect the health of the public and the environment'*
by:
 - **Providing data that supports understanding**
 - Sources
 - Precursors
 - Fate
 - Data Analysis

Philosophy

We promote and protect the health of the public and the environment

The data is the is the standard by which the success of our effort is measured.

Questions?